ELECTRONIC SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
HANSCOM AIR FORCE BASE, MASSACHUSETTS

FORMAL

Environmental Assessment

PHASED ARRAY WARNING SYSTEM

PAVE PAWS

OTIS AFB, MASSACHUSETTS

MARCH 1976

Air Force
Environmental Planning Division
(HQ USAF/CEVP)

Room 5B269
1260 Air Force Pentagon
Washington, DC 20330-1260

16 JUL 93

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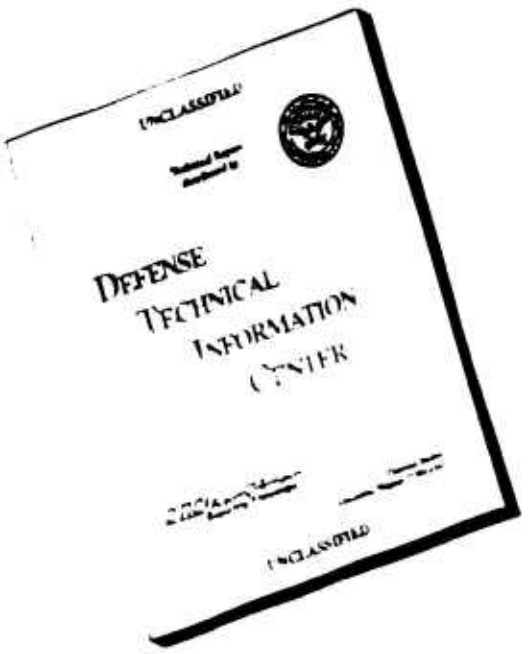

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AIR FORCE SYSTEMS COMMAND

HEADQUARTERS ELECTRONIC SYSTEMS DIVISION

ADDENDUM 1 TO ENVIRONMENTAL ASSESSMENT OTIS AFB, MA OF AUGUST 1975

FEBRUARY 1976

PHASED ARRAY WARNING SYSTEM (PAVE PAWS)

PROJECT NUMBER 2059
ELEMENT NUMBER 12432F

OTIS AFB, MA

Approved by:

PAUL T. McEACHERN, Lt Colonel, USAF
System Program Director
PAVE PAWS SPO

MELVIN W. WITHAM
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MAR 17 1976

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AIR FORCE SYSTEMS COMMAND
HEADQUARTERS ELECTRONIC SYSTEMS DIVISION

ADDENDUM 1
16 FEBRUARY 1976

ENVIRONMENTAL ASSESSMENT (EA) FOR PHASED ARRAY WARNING SYSTEM (PAVE PAWS) AT OTIS AFB, MA

1. By this Addendum, the PAVE PAWS EA for Otis AFB, approved October 31, 1975, is changed to reflect a refinement in the calculation of hazard distances, based on average levels of radiated power which are more nearly representative of the phased array type of radar system; and to describe differences in the baseline system resulting from a growth option.

2. The following change pages incorporate all new or revised material in the PAVE PAWS EA.

Section	Page
a. Basic EA	ii, 2, 3, 7, 13, 18, 19, 20, 21, 22, 40, 44, 45, 46
b. Appendix I	Figure 7, 8
c. Appendix III	Table 3
d. Appendix V	Page 1, 2, 7, 11, 13
	Figure 2
Attachment 2	Page 1, 2, 3, 4, 5, 6, 7
3	Page 13 (Rev. 2 and 3)
4	Page 3, 7, 8

3. The change on each page has been identified by a line in the margin.

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AIR FORCE SYSTEMS COMMAND

HEADQUARTERS ELECTRONIC SYSTEMS DIVISION

ADDENDUM 2 TO ENVIRONMENTAL ASSESSMENT

OTIS AFB, MA OF MARCH 1976

JUNE 1976

PHASED ARRAY WARNING SYSTEM (PAVE PAWS)

PROJECT NUMBER 2059
ELEMENT NUMBER 12432F

OTIS AFB, MA

Approved by:

PAUL T. McEACHERN, Lt Colonel, USAF
System Program Director
PAVE PAWS SPO

SUMNER S. SACHS, Lt Colonel, USAF
Chairman, ESD Environmental
Protection Committee, ESD/DE

This action does not require an environmental statement using the criteria of AFR 19-2a

WALLACE H. BROWN
Acting Director, Environmental Protection
DCS/Engineering & Services

JUL 14 1976

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Addendum 2 to Otis AFB

Environmental Assessment

A. This addendum is submitted to indicate a minor change in boresiting of the PAVE PAWS building. The original boresite provided azimuth sector coverage from 355°T to 235°T. The new proposed boresite will provide azimuth sector coverage from 347°T to 227°T. The total azimuth coverage of 240° is unchanged. Vertical (elevation) coverage from 3° to 85° also remains unchanged.

B. This change was requested by Aerospace Defense Command (ADCOM), the operating and using command. An analysis made by them and confirmed by MITRE Corporation was performed taking into account the latest threat with the auxiliary detection facilities that exist.

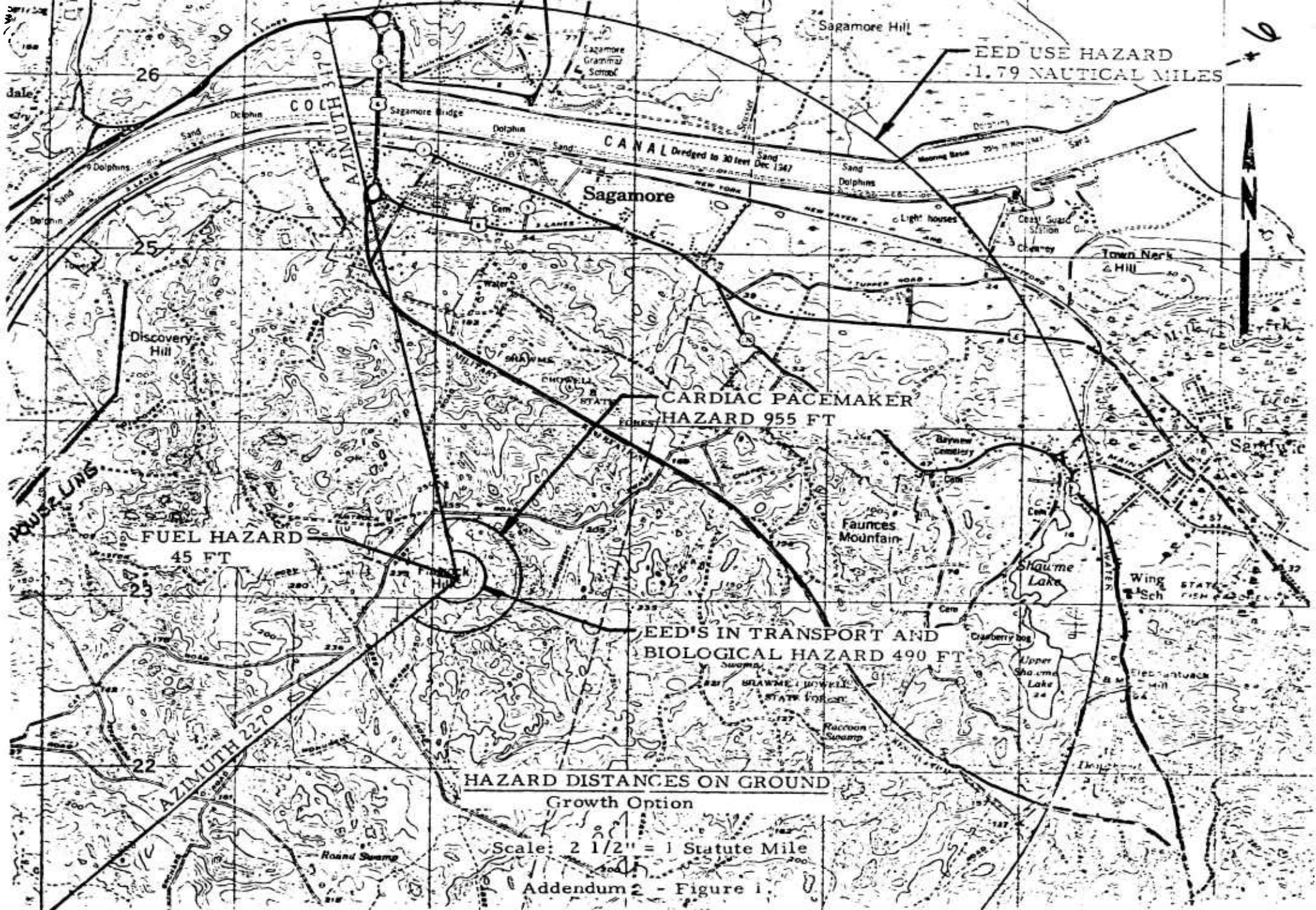
C. Based on the new boresite, Figure 1 shows the azimuth coverage rotated 8 degrees counterclockwise. This figure is an update of Figure 8 in Appendix I of the Environmental Assessment. A slight decrease in EED Use and Cardiac Pacemaker Hazard Distances are shown since they are now calculated from the peak radiated power of the selected contractor's radar. Fundamentally, there is no change in environmental impact. An area to the Southwest consisting of a sector 8 degrees wide (235° to 227°) is no longer in the azimuth coverage but the sector to the North (347° to 355°) is now included.

D. There is no change in the radiation hazards except for the slightly lower distances and the different areas affected. The buffer zone fence 1000 ft from the facility will be appropriately constructed in the sector which includes the new azimuth angles. The total number of TV sets that theoretically could be interferred with on Channel 10, from Providence, R.I. will remain unchanged since the number of sets lost in one sector is essentially balanced by the number of sets gained in the new sector.

E. The Sagamore Bridge across the Cape Cod Canal is now included in the azimuth coverage of PAVE PAWS. The highest point of this structure (top of the arch) is 275 feet above mean low water. The center of the PAVE PAWS array will be about 25 feet higher in elevation than this point on the bridge and a distance of 1.6 statute miles from it. At a 3° beam elevation the lower extremity (3 db point) of the main beam will be about 320 feet above the highest point of the bridge and 442 feet above the roadbed. The main beam will never illuminate the bridge because the radar will be designed to preclude lowering of the beam below its minimum operating elevation thereby keeping the beam a considerable distance above the highest point of the bridge.

There will be no sidelobe radiation hazards at any point on the Sagamore Bridge due to sidelobe radiation.

F. There is no change to the probable impact of this System on pollution effects, effects on energy supply and natural resources, effects on land use and management.


EED USE HAZARD
1.79 NAUTICAL MILES
AZIMUTH 317°
Sagamore Hill
Sagamore
Sagamore Bridge
CANAL Dredged to 30 feet Dec. 1947
Discovery Hill
CARDIAC PACEMAKER
HAZARD 955 FT
FUEL HAZARD
45 FT
EED'S IN TRANSPORT AND
BIOLOGICAL HAZARD 490 FT
AZIMUTH 227°
Faunces Mountain
Shawme Lake
Town Neck Hill
Round Swamp
Raccoon Swamp
HAZARD DISTANCES ON GROUND
Growth Option
Scale: 2 1/2" = 1 Statute Mile
Addendum 2 - Figure 1.

ENVIRONMENTAL DETERMINATION
FOR
PROPOSED PHASED ARRAY WARNING SYSTEM (PAVE PAWS)
AT
OTIS AIR FORCE BASE, MASSACHUSETTS
DATE: 12 MARCH 1976

Proposed Action: The US Air Force proposed to install and operate a Phased Array Warning System (PAVE PAWS) at Otis AFB, Massachusetts. Pave Paws is a long range phased array warning sensor which will be built under contract that is proposed for award in March 1976.

The purpose of the system is the detection and characterization of Sea Launched Ballistic Missiles (SLBM) launched against the continental United States, with the secondary mission of supporting the US Air Force Space Track System with Earth Satellite Vehicle surveillance, tracking and radar space object identification. The system is projected for installation during the nest three years.

Determination: After a careful review of the formal environmental assessment and consulting with appropriate representatives of the Air Force Systems Command Headquarters Staff, I have determined that the proposed action is not a major federal action with significant adverse impact on the quality of the human environment. I have also concluded that the action is not likely to be highly controversial with regard to its environmental impacts. This determination is based on the following:

1. The adverse effects from electromagnetic emanations will be kept to a minimum by siting the radar in a location contained within a government reservation, away from population centers, parks, historical sites, transportation routes and other systems and equipments. Frequency management and guard bands will be employed to minimize interference with other systems. Hazard areas will be fenced and posted with warning signs.

2. If TV sets are affected by the radar, they will be modified at Air Force expense by installing a small, inexpensive filter trap on each set to eliminate the problem. The baseline/growth option radar could have a possible effect on 50 percent of the TV sets in the effected area. This amounts to a potential 350 and 850, respectively.

3. The construction and operation of the Pave Paws radar at Otis AFB will have several socio-economic effects. The radar project will involve several million dollars in construction and installation over a three year period, and approximately two and a half million dollars a year in federal payroll when the radar becomes operational. In addition, there will be an increase in community employment to provide goods and services required for the radar and its operating per personnel with their families. An economic loss will occur in the areas near Charleston AFS, ME and Fort Fisher, NC, of about $1,000,000 per year in federal payroll for each site, due to the shutdown of the AN/FSS-7 radar system, which will be phased out when the Pave Paws East radar is operational. The phaseout of the AN/FSS-7 radar plus the

Long Range Radars that will be superceded by the Joint Surveillance System will have the combined effect of reducing population, employment and wages at Charleston by 2.5 percent and Fort Fisher by 2.0 percent.

4. Some pollution of the atmosphere will result from the generation of electric power with diesel driven generators to operate the radar site and from the vehicular traffic travelling to and from the operational site. The power plant will be designed to conform with federal, state and local air quality and noise suppression standards. The vehicular generated pollution will result from 100 to 200 vehicles per day, which is insignificant when compared to the average daily summer crossings of the Cape Cod Canal of 42,500 trips per day.

5. Water for the site will be obtained from a new deep well and water distribution system at the radar site. Domestic sewage will receive secondary treatment as a minimum, prior to discharge through subsurface drains. Further filtration will occur as the effluent percolates 150 to 200 feet to the water table. Contamination of other water systems is unlikely since there are no wells, public or private, within a mile of Flatrock Hill. In summary, the effluent from the sewage system and other drainage systems will be treated to meet federal, state and local water quality standards.

6. An unsafe area for unshielded electroexplosive devices (EED) extends for a sector 1.89 nautical miles from the radar site. This area includes parts of the towns of Sandwich and Sagamore. The need to use dynamite in this area is rare because of the sandy composition of the soil. A permit from the fire department is required for the purchase and use of explosives. Since the area is unsafe for electric blasting caps, a restriction could be imposed upon all dynamite blasting in the area by requiring the use of fuses for detonation in lieu of electric blasting caps (EED). EEDs that are being transported on the highways are regulated by Commonwealth of Massachusetts, Department of Public Safety Regulation FPF-12 and are subject to the criterion for EEDs in transport or storage mode requiring a minimum safe distance of 265 feet (for baseline system) or 490 feet (for the growth option) for Pave Paws. The closest road is the Mid-Cape Highway, Route 6, which approaches to within 3600 feet of the radar site; consequently, there is no hazard involved in the highway transport of EEDs.

7. The nature of main beam illumination and the associated radiation effects do not require an air traffic control restricted area about the radar because of biological or cardiac pacemaker hazards. The Federal Aviation Administration flight restriction (F-4101 for Camp Edwards) now in existence provides adequate clearance. The regional office of the Federal Aviation Administration has been kept informed of the Pave Paws program from the earliest consideration of Otis AFB as the East Coast site and at present can see no need to change this restriction. Military Notams will be used to advise aircrews of inflight separation criteria for aircraft carrying EEDs (if required). The radiation from the radar will not affect aircraft UHF radio receivers due to a difference in their operating radiofrequencies.

FRANCIS J. [illegible], [illegible], USAF BSC
Director, Environmental Protection

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AIR FORCE SYSTEMS COMMAND
HEADQUARTERS ELECTRONIC SYSTEMS DIVISION

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ENVIRONMENTAL ASSESSMENT
DATE PREPARED - AUGUST 1975
REVISION #1 - OCTOBER 1975
REVISION #2 - FEBURARY 1976

PHASED ARRAY WARNING SYSTEM (PAVE PAWS)

PROJECT NUMBER 2059
ELEMENT NUMBER 12432F

OTIS AFB, MA

Approved by:

PAUL T. MCEACHERN, Lt Colonel, USAF
System Program Director
PAVE PAWS SPO

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Chairman, ESD Environmental
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Prepared in accordance with AFR 19-2 in compliance with the National Environmental Policy Act of 1969.

PROPOSED CONTRACT AWARD - JANUARY 1976.

An environmental statement is not required for this action.

Approved

FRANCIS J. SMITH, Col, USAF BSC
Director, Environmental Protection
DCS/Engineering & Services

OCT 31 1975
MAR 17 1976

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1. Introduction.

This environmental assessment is based on studies conducted by the U.S. Air Force to determine the probable impact to the environment which will result from the installation and operation of PAVE PAWS at Otis AFB, Massachusetts. A separate assessment addresses the west coast site, Beale AFB, California. The studies include site surveys, map studies, analyses of electromagnetic radiation effects, evaluation of geographic coverage, and the investigation of the environmental and socio-economic conditions in the surrounding areas.

a. Project Description.

The PAWS will consist of two long range, two faced, phased array warning sensors to be installed in the Continental United States (CONUS), one on the east coast and the other on the west coast. The sensors will be located on government property at Beale AFB, Yuba County, California, and at Otis AFB, Barnstable County, Massachusetts. The system will be utilized primarily for detection and attack characterization of Sea Launched Ballistic Missiles (SLBM's) launched against the CONUS, with a secondary mission of supporting the U.S. Air Force Space Track System with Earth Satellite Vehicle surveillance, tracking and radar space object identification. Operations will be conducted 24 hours per day, 7 days per week for an anticipated minimum 10 year life. Approximately 200 operating and maintenance personnel will be required at each location. The project is planned for installation during the next three years.

Since the performance of the PAWS will surpass that of the present ground based SLBM warning system, implementation of the new system on the east and west coasts of the CONUS will permit the phasing out of the AN/FSS7

radars now located at Mill Valley AFS, CA, Mt Hebo AFS, OR, Fort Fisher AFS, NC and Charleston AFS, ME. The termination of the AN/FSS-7 system will result in a reduced Air Force mission at each of the locations listed, with a corresponding beneficial decrease in pollution of the environment, and an adverse economic impact to the local communities. It should be noted that there are other aircraft surveillance missions at those sites, in addition to that of the AN/FSS-7 radar, which missions will also be phased out as part of the ADC consolidation policy being instituted in the next few years. This assessment will discuss the new radar at Otis AFB and the combined impact of the various mission reductions at each of the AN/FSS-7 locations on the east coast. (See Appendix VI) Discussion of the AN/FSS-7 locations on the west coast is covered in a separate environmental assessment prepared for the western PAVE PAWS site.

Possible future expansion of PAWS may locate additional sites in the southern states. The environmental impact of future system expansion will not be described in this assessment, but will be covered when and if such expansion should become imminent.

The proposed phased array radar will function with electronically steered, narrow, pencil shaped beams which sweep the surveillance volume with an extremely rapid scan in azimuth and elevation. The PAVE PAWS will accomplish surveillance while tracking targets or acquiring space object identification information. Consequently, surveillance will be performed at all times and requires 40% of the radiated energy. The remaining 60% of the available energy will be used to perform target tracking or spare object identification when required. Due to the rapid scan action of the radar, any given point within the surveilance volume will be illuminated by the beam for only a fraction of a second at regular intervals.

The radar will be housed in a structure which very likely will be designed as a multi-story building with two sloping sides for the antenna array faces. The structure may be approximately 100 feet high, and 100 by 150 feet at the base, and will be designed to accomodate the shift personnel for operating and maintaining the radar site. The construction at each site will include the necessary supporting utilities, such as water supply and distribution, electric power generation and distribution, sewage and waste water treatment and disposal, access road, parking areas, gatehouse, fencing, fuel storage, and any other construction which may be required to augment the support facilities at the host base. The radar construction area will require approximately 4 acres of land. An additional area for a radiation hazard buffer zone will extend in a radius of about 1000 feet from the radar. This buffer zone will be fenced and posted to exclude personnel and large animals. See Figure 1, Appendix 1, for an artist's concept of the installation.

b. Existing Site Characteristics.

(1) On the east coast a number of candidate locations were considered, and following a series of map studies, site surveys and evaluations, Otis AFB was selected as the most suitable site for the PAVE PAWS radar. Appendices II and III contain the site survey reports, and a chart of comparative ratings for the sites evaluated.

Within Otis AFB, four alternate locations were investigated; Pine Hill, Deer Horn Hill, Hill 280 and Flatrock Hill. These sites are shown in Figures 2, 3, 4 and 5, Appendix I. Flatrock Hill was chosen as the prime location for the reasons described in the Alternatives section, paragraph 4 of this assessment.

(2) The terrain along the entire western side of Otis AFB consists of irregular wooded hills, ranging in elevation from 50 to 300 feet above main sea level. This land formation is a part of the Buzzard's Bay Moraine, a "knob and kettle" deposit of glacial till resulting

from the last ice age. The soil is composed of silt, gravel and sand heavily interspersed with large stones and boulders, all of which settled in the present configuration of small hills and deep hollows as remnants of the receding glacier melted in place. The area is mostly undeveloped, except for a network of light duty and unimproved roads throughout the firing range. A hard surfaced, medium duty, 2 lane road (Perkins Road) provides excellent access from the built up portion of the base to the Pine Hill location. Access to Flatrock Hill, Hill 280 and Deer Horn Hill is more difficult, involving narrow, unimproved dirt roads and trails in the outlying sections. Approximately one mile of dirt road connects the Deer Horn Hill location to the nearest paved road (Lee Road); and roughly three miles of dirt roads must be traversed to reach the Flatrock Hill/Hill 280 area from the southwest side of the base, or four miles of slightly better dirt roads from the southeast side. The Hill 280/ Flatrock Hill area also can be reached more directly from off-base, along Sagamore Road or Jarvis and Flatrock Roads (0.8 miles and 1.5 miles of dirt road respectively), if an entrance to the base is provided on either of those routes.

(3) All of the candidate sites are located on hilltops, consequently the natural drainage should flow in several directions away from the high ground. However, there are no identifiable water courses to receive the flow in this "knob and kettle" terrain. Rather, the nature of the topography, vegetation and soil is such that the surface run off of precipitation is slow, with much of the drainage being absorbed by the vegetation and the pervious soil. Water which is not absorbed during initial runoff tends to pond in the nearest kettle holes where it

soon percolates through the soil to replenish the underlying ground water supply. Some of the kettles are deep enough to expose the ground water table, thus constituting small permanent ponds. There are only a few such ponds on Otis AFB, and none within three quarters of a mile of the candidate radar sites. There are no brooks or rivers within the government reservation.

(4) There is an existing water supply system at Otis AFB derived from 3 deep wells. This system is presently used far below capacity due to the overall decrease in military activities at the base in recent years. The major source of fresh water on Cape Cod consists of a large reservoir of groundwater underlying the entire Cape, the upper elevation of which is about 50 to 60 feet above sea level near each of the prospective radar locations, diminishing to sea level along the shoreline. Although the water supply is abundant, and has furnished the needs of the inhabitants to date, there is concern that continued development of the Cape will eventually overtax the supply.

(5) At Pine Hill there are several unused structures, which at one time had served a Navy radar installation. Within a 400 X 400' fenced enclosure there are a technical equipment building, a diesel generator building, two tower structures, commercial power, a well water supply and a small sewage disposal system. These facilities are in poor repair and would be replaced with PAVE PAWS facilities. At Deer Horn Hill and Flatrock Hill there are no existing facilities. Hill 280 is located immediately adjacent to a 115KV electric power transmission line which would need to be relocated to avoid conflict with PAWS at that site.

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(6) The center of the developed portion of Otis AFB with its airfield and supporting activities, is 3½ miles southeast of Pine Hill, 3 miles to the east of Deer Horn Hill, and about 6 miles to the south of Hill 280 and Flatrock Hill. The military housing area extends to within 1600 feet of Deer Horn Hill. The existing facilities at Otis AFB will provide most of the support for PAVE PAWS and its operating personnel. In 1973, during the realignment of Air Force activities in Massachusetts, manpower adjustments at Otis AFB resulted in a decrease of more than 600 military and civilian potitions. Thus it is apparent that present facilities at Otis have the potential to support more than the 200 personnel required for PAVE PAWS, subject to some modification and repair work.

(7) The military reservation is situated in the towns of Falmouth, Bourne, Sandwich and Mashpee. The year-round population for these towns was reported as 30,618 in the 1970 census, but has expanded to about 36,000 in 1975. Figure 6 in Appendix I shows an approximate distribution of the population surrounding Otis AFB. Table 3 in Appendix III lists the distances of the alternate sites at Otis from the surrounding population centers. An additional 80,000 tourists and summer inhabitants inflate the population of that area during the summer months. Tourism, constitutes a major element in the economy of the area, (about 22% of the Cape's total payrolls in 1970). An approximate proportioning of the source of personal earnings on Cape Cod in 1969 is indicated in Table I, (Appendix III).[1]

[1]Based on data contained in Cape Cod Economic Base Study, October 1972, Cape Code Planning and Economic Development Commision.

The large percentages shown in Table 1 for trade and service industry earnings reflect the influence of the tourist influx to the Cape. The figures show the minor importance of farming and manufacturing as sources of area income, and the very significant part which the government payroll and the tourist related trade and service earnings play in the Cape economy.

The seasonal nature of Cape Cod's resort industry, and the declining activity in fishing and agriculture have resulted in unemployment problems in sections of the Cape. In June 1975, the unemployment rate for the Cape was 16.3% compared to 9.2% for the nation.

(8) The two major highway corridors to the outer Cape and to the southern shores of the Cape, (Routes 6 and 28), parallel the northern and western boundaries of Otis AFB. These limited access roads are heavily travelled, causing some congestion at the entrances to the base, particularly in the summer months. Travel from the base to the nearest sizeable business centers in Falmouth, Buzzards Bay and Sandwich, and to areas north of the Cape Cod Canal involves the use of these highways.

(9) There are many historic attractions on Cape Cod, particularly in the four towns in the vicinity of Otis AFB. Glassworks, Colonial [illegible], mills, churches, trading posts, meeting houses and Indian artifacts draw thousands of visitors each year. Despite the wealth of historic landmarks surrounding Otis there are no historic sites within the base at the locations proposed for the PAVE PAWS radar.[2]

(10) School facilities located at Otis AFB consist of three elementary schools and a junior high school comprising a total of 18 classrooms and 2

[2]Confirmed in discussion with the Chairman of the Bourne Historical Commission.

special classrooms. One of the elementary schools is not used at present, but the rest of the facilities are actively operated as part of the Bourne school system. The superintendent of Schools in Bourne, mentioned that there are 14 empty classrooms in the school system, (June 1975), resulting largely from the reductions in manpower which have occurred at Otis AFB in recent years.

(11) An ecological survey of the candidate locations for PAWS at Otis AFB has been conducted by the Environics Branch of the Air Force Civil Engineering Center, (AFCEC/OL-AA), Kirtland AFB, New Mexico. The resulting report (Appendix IV) describes the predominant vegetation in the area as Pitch Pine and Scrub and White Oak with shrubbery consisting of ferns, greenbriar, grape, bearberry, sheep laurel and low bush blueberry. The nature of this vegetation has been affected considerably by the recurring forest fires which characterize the area. The Otis firing range has caused some of the fires. The Pitch Pine, which is well adapted to rapid colonization of fire ravaged areas, is at the same time very vulnerable to burning. Thus the cycle continues, with normal growth of many of the large trees typical to this region held back by the Pitch Pine and fires.

The dense growth of vegetation throughout the western and northern portions of the reservation provides suitable habitat for 175 to 225 white tail deer and other wildlife (Appendix IV). The western side of the base serves as a corridor between the Crane Wildlife Management Area, south of Otis, and the Otis AFB Wildlife Management Area established by the State in the northern portion of the base. There are no rare or endangered species known to inhabit these areas.

Migratory birds transit the Cape Cod area. Although birds will avoid microwave radiation, the sporadic nature and limited critical radiation field of PAVE PAWS should have little effect on the existing routes or the birds themselves. See Appendix IV, Attachment 1.

2. Relationship of Proposed Action to Land Use, Plans, Policies and Controls for the Affected Area -

a. The proposed radar site at Flatrock Hill is located within the firing range operated and controlled by the Massachusetts Army National Guard. The installation of PAVE PAWS would necessitate the relocation of several firing positions and connecting roads in the general area of the radar and would require an adjustment in other range activities, (bivouac, aerial observation, transportation and storage of electroexplosive devices) to avoid mutual interference. Initial approval to use Flatrock Hill for PAVE PAWS has been obtained from the State Adjutant General and the Office of the Governor during preliminary discussions.

The proposed radar site also falls within the Otis AFB Wildlife Management Area, which with the Crane Wildlife Area and the interconnecting wildlife corridor, comprise the largest single natural habitat on the Cape. (Appendix IV) The area is opened briefly each year for hunting. The radar installation should not interfere with the wildlife or hunting activities in the area, except to prevent access to that part of the land fenced off for the radar. This fence will prevent personnel & large animals from entering the radiation hazard area.

b. The Otis Task Force of the Massachusetts Joint Commission on Federal Base Conversion has had several studies conducted to evaluate possible future uses for portions of Otis AFB which are excess to the needs of the Air Force. The results of these studies are contained in the following reports:

(1) Housing Conversion Analysis for Otis Air Force Base, Cape Cod, Massachusetts - July 1974. prepared by Richard White Associates, Boston, MA.

(2) The Potential Use of Otis Air Force Base for Recreation - December 1974 - prepared by State Street Consulting Group, Boston, MA.

(3) Otis AFB Visitor/Craft Center Feasibility Study - February 1975 - prepared by David A. Crane & Partners/DACP, Inc - Boston, MA in association with Economics Research Associates.

None of the uses proposed in these studies would conflict with the installation and operation of the PAVE PAWS radar at Flatrock Hill.

c. Other plans for the use of Otis AFB include the construcion of a national cemetery by the Veterans Administration on approximately 750 acres of land to the north of Deer Horn Hill; civilian re-use of the airfield; civilian re-use of the railroad spur into Otis AFB; and the construction of a highway extension (Route 25) through the northern corner of the base, connecting Routes 28 and 6. None of these projects would conflict with the PAVE PAWS installation at Flatrock Hill, although the proposed extension of Route 25 would pass within 2700 feet of the radar location. Preliminary discussions with the Massachusetts Department of Public Works indicate that minor realignment of the highway northward may be possible to assure the maximum possible safety distance from the radar.

3. Probable Impact of the Proposed Action on the Environment.

a. Pollution Effects

(1) Air Quality - Pollution of the atmosphere will result from the generation of electric power with diesel driven generators to operate the radar site and from the vehicular traffic travelling to and from the operational site. Two independent sources of electric power are required and will be provided from a new government power plant as well as from the local power company. The source drawn on at any specific time is at the option of the operator. Guidelines will be established by the operating command. Less significant, short term pollution will also occur during construction, consisting of dust from the movement of earth, dust from traffic on dirt work roads, and the products of combustion from the construction vehicle engines. Heating of the radar facility will be accomplished by utilization of waste heat from the radar equipment and from the diesel generator plant. Disposal of brush, stumps, logs and construction debris will not involve open burning, in consonance with State requirements.

Degradation of the atmosphere from automotive emissions during construction and during the operation of the radar site will be relatively insignificant when compared to the volume of traffic on the highways surrounding the military reservation. Studies conducted by the Department of Public Works indicate that in 1972 the average daily crossings of the Cape Cod Canal were 42,500 trips per day. Presently, the average daily summer crossings of the Canal are about 71,500 vehicles, with peak figures of 85,000 trips daily on Saturdays in July and August. The polluting effects of the 100 to 200 vehicles per day associated with PAVE PAWS will be relatively minor.

Dust caused by land clearing, earth work, and general construction activity on dirt roads will be controlled by construction specifications to minimize pollution. This may involve sprinkling, chemical treatment, light bituminous application, mulching or similar methods. Access roads and parking areas will be paved upon completion of construction, and the generation of dust will decrease almost entirely at that point in time.

Contract award for the acquisition/installation of the PAVE PAWS radar facility will not occur for several months, consequently the details of the radar design and the total electric power requirement at the site are not yet known. However, the power requirement should not exceed 4000 KW as a worst case, and the corresponding diesel fuel consumption would be approximately 300 gallons per hour. This usage would produce about 2.4, 0.3 and 0.9 pounds per hour of sulphur dioxide, particulates and nitrogen oxide respectively. A secondary effect of the PAVE PAWS project at Otis AFB will be the phasing out of the AN/FSS-7 radars at Charleston AFS, ME, and Fort Fisher AFS, NC, resulting in a decrease in local atmospheric pollution corresponding to a savings in fuel consumption of 40 gallons per hour per site, for a total of 80 gallons per hour.

The ambient quality of the air in the project area at Flatrock Hill should be well within State and Federal standards at the present time, since there are few contributing sources to the pollution

of the atmosphere in the immediate area. However, depending upon the wind direction and the condition of atmospheric stability, pollutants generated by the electric power plant in Sandwich, the heating plant at Otis, aircraft at Otis, artillery at the firing range and motor vehicles on the major highways surrounding Otis tend to degrade the air quality at Flatrock Hill in varying amounts.

The diesel fuel oil to be used at the PAWS power plant will be type DF2, which is free of all additives except octane improvers. The use of this high quality fuel assures good combustion under all conditions of operation. In addition, the engine generators will be selected with sufficient oversize capacity to assure that the exhaust is clean.

(2) Water Quality - Water for fire and personnel use and for equipment cooling will be obtained by constructing a new deep well and water distribution system at the radar site. Per capita consumption for personnel use is based on 50 gallons of water per 8 hour period. Thus the personnel water consumption at the radar site is estimated at 10,500 gallons per day. This volume is equivalent to the normal domestic requirements of a population of 70 in a town water supply system. In addition to the domestic requirements, there will be a need for equipment cooling water. The system anticipated for cooling the radar equipment will be semi-closed and will require, after the initial input, 60 gallons per day of make-up water. The water lost will be due to evaporation.

There will be no discharge of cooling water. Water for fire protection will be stored in a ground reservoir located at the site.

The total estimated water use of less than 11,000 gallons per day for PAVE PAWS will have minor impact in depleting the ground water source in that part of the Cape, particularly in view of the fact that the domestic waste water will be treated and returned to the soil. By this procedure the level of the ground water table will be maintained virtually unchanged.

Potential water pollution is limited to subsurface waters inasmuch as there are no ponds or streams within a mile and a half of Flatrock Hill, and there are no drainage patterns which would direct surface flow from the site to any such body of water. Domestic sewage will receive secondary treatment as a minimum, prior to discharge through subsurface drains. Further filtration will occur as the effluent percolates downward 150 to 200 feet to the water table. The water supply system for the new radar will be located and designed to avoid contamination from that effluent. Contamination of other water systems is unlikely since there are no wells, public or private, within a mile of Flatrock Hill. Storm drainage from the buildings and paved areas at the radar site will contain fertilizers, insecticides, road salt, oils and minerals, which ultimately will reach the ground water, however, the quantities of such pollutants are expected to be small. In accordance with Air Force policy and regulations, care will be exercised to avoid such contamination during the operation of the site.

An underground storm drainage system is not contemplated; rather, the runoff from the developed area will be carried on the surface for distribution as sheet runoff over large areas of vegetation, where absorption into the soil will occur. Where channeling of the drainage is unavoidable the design will protect against erosion.

During construction, clearing and grading of the site will expose the soil, which could result in erosion and the unplanned movement of soil to the low areas adjacent to the area being developed. The construction specifications will require special procedures to minimize the possibility of such erosion.

About 100,000 gallons of fuel oil will be stored in tanks at the radar site. The possibility of oil spillage will be minimized by designing the facility in accordance with applicable corrosion protection standards, and by engineering the installation to use high liquid level alarms, and facilities for regular pressure testing of the tanks and piping.

The shutdown of the AN/FSS-7 radars will reduce water consumption, sewage disposal, and water pollution commensurate with a manpower reduction of 76 at each location.

(3) Solid Waste Disposal - Solid wastes generated at the proposed radar site will be disposed of in the sanitary landfill now operated at Otis AFB. The present landfill site has sufficient capacity to operate for another five years with the added load from PAVE PAWS. In addition, there are provisions and ample acreage to expand the existing landfill site and to open up other landfill operations when the present site becomes exhausted. The quantity of wastes produced at the PAWS site will be minor since personnel will not reside there. Household waste material generated at the individual residences of the PAVE PAWS personnel will be handled through the existing waste disposal systems at each of the locations involved. The total increase in solid wastes resulting from the PAVE PAWS installation at Otis will not approach the volume produced prior to the curtailment of Air Force activities at the base in 1973.

Pollution from the disposal of solid wastes at the AN/FSS-7 radar sites will be reduced by the termination of the AN/FSS-7 radar system.

(4) Noise - The principle noise source at the radar site will be the power plant with its diesel engines. Silencers will be used to provide a high degree of sound attenuation. In addition, the power plant design and materials of construction will be selected to minimize the noise level. The predicted sound pressure levels at the facility measured at a distance of one hundred feet will range from 70 db* at 37.5 cycles per second to 50 db at 10,000 cycles per second. These sound levels will decrease by 6 db with each doubling of the distance from the sound source. Further attenuation is afforded by the vegetation in the area. Thus, the 70 db sound pressure level will drop to 40 db or less at 3200 feet away from the diesels. The nearest highways and residences are beyond that distance. Acceptable noise levels

* above 0.0002 dyne per cm^2

for the average residential area are in the 40 to 50 db range; thus the contribution of less than 40 db from the new radar to the existing background noise levels in the surrounding residential areas, should be hardly noticeable. Appropriate federal, state and local noise standards will be observed in the design of the power plant.

Noise resulting from the generation of electric power for the AN/FSS-7 radars will cease with the termination of that system.

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(5) ELECTROMAGNETIC RADIATION - (EMR)

EMR was considered the most serious potential impact to the environment associated with the PAVE PAWS project. A thorough study has been made for the baseline system and for a system with a growth option. (See Appendix V). The effects of radiation from the PAVE PAWS radar were considered for all possible conditions where conflicts might arise due to frequency/amplitude/time characteristics of the radiated energy. PAVE PAWS will use solid state power sources thus reducing the peak power required to accomplish the mission. This in turn will result in minimized EMR. Effects considered include those on living creatures, fuel, electroexplosive devices (EED's), cardiac pacemakers, and receiver burnout. Electromagnetic Interference (EMI) experienced by other electronic equipments due to sub-harmonics, fundamental or harmonic frequencies was considered. In addition, the phenomenon known as "high power effect" (HPE) was considered and its effect on the surrounding area analyzed.

The radiation effects, sources of EMI, an analysis of electromagnetic compatibility impact on the surrounding environment and local air traffic considerations are included in Appendix V, attachments 1,2,3 and 4. In the criteria used for determining hazard distances from the site, assumptions were made for the radar transmitter parameters that are based on conservative best available information. Calculation of the PAVE PAWS average radiated power is based upon the allocation of energy to the space object identification (SOI) and track mission. The maximum average energy used to illuminate any target results from the use of 60% power for SOI while 40% power is retained to accomplish surveillance. Each calculation is a "worst case" for that situation. Hazard distances based on sidelobe radiation assumes that the radiation is continuous since a sidelobe will always illuminate the ground regardless of the position

of the main beam. Both critical distances and duration of illumination must be considered for the main beam. Where exposure time is the significant criteria, i.e., short term biological exposure or cardiac pacemaker, critical distances for main beam illumination significantly decrease or are not applicable. The nature of the basic assumptions made in establishing critical distances result in additional built in safety factors:

(a) Consideration of sidelobe radiation was made for objects on the ground and assumed free space radiation. The actual ground path, covered with trees and underbrush, results in additional attenuation to the sidelobe radiation.

(b) Far field power densities are assumed for all distances since they are easily calculated from the radar parameters. In the near field or Fresnel region (up to approximately 4000 ft. from the antenna) these calculations are conservative. Lower power levels actually exist.

Radiation hazards will not occur at Otis AFB or the surrounding communities if the appropriate safe distances for each of the hazards are observed. Hazard ground distances required because of sidelobe radiation are illustrated in Appendix I, Figures 7 & 8. All hazard distances due to main beam and sidelobe radiation are shown in Appendix V, Attachment 2. These distances are only applicable in the 240° radiation sector. Radiation outside of the 240° sector is negligible. Characteristic of phased array antennas, all the radiated energy is directed from the antenna face and none is radiated from the sides or rear of the radar building. Fences and signs will protect and provide warning against biological and cardiac pacemaker hazards on the ground.

There are no documented cases of interference with hearing aids from radars of this type. The feasibility of a sporadic interference caused by high power effect is conceded, however, should this situation arise it would have to be handled on a case by case basis. Susceptibility would vary with make, position and proximity to the radar and shielding about the wearer. This interference would be sporadic in nature and would not create a serious impairment to the wearer.

Figures 7 and 8 in Appendix I show the unsafe sector of radius 1.89n. mi for unshielded electroexplosives devices (EED). This sector includes part of the Army National Guard firing range and parts of the towns of Sandwich and Sagamore. Discussions with the Army National Guard indicate that there will be no difficulty in controlling the military use of EED's. In the surrounding towns the need to dynamite is rare because of the sandy composition of the soil, however, it is possible for an individual to obtain dynamite and blasting caps for personal use within the area. A permit from the fire department for the purchase and use of the explosives is required. Since this area is unsafe for electric blasting caps, a restriction would be imposed upon all dynamite blasting in the area by requiring the use of fuses for detonation in lieu of electric blasting caps (EED). The detonating fuses are not susceptible to electromagnetic radiation and can be used safely anywhere within the hazard zone.

EEDs that are being transported on the highways are regulated by Commonwealth of Massachusetts, Department of Public Safety Regulation FPF-12 and are subject to the criterion for EEDs in transport or storage mode requiring a minimum safe distance of 265 ft. or 490 ft. (App 1 Fig 7,8)

for PAVE PAWS. The closest road to these minimum distances is the Mid-Cape Highway, Rt. 6, which approaches to within 3600 ft of the radar site, consequently, there is no hazard involved in the highway transport of EED's. During the construction phase of PAVE PAWS and when the radar is capable of radiating a full powered beam, actual field measurements will be made on Rt. 6 to verify that the field strength (power density) is not exceeded. In view of the higher elevation of Flatrock Hill than Rt. 6 and the abundance of trees and vegetation, experience with field measurements should indicate a much lower level of field strength allowing for a much safer distance than calculated.

The nature of main beam illumination and the associated radiation effects do not require an air traffic control restricted area about the radar because of biological or cardiac pacemaker hazards. Normal FAA flight restrictions now in existence provide adequate clearance. Military Notams will be used to advise aircrews of required inflight separation criteria for aircraft carrying EED's. (See App. V, attachment 2).

Possible interference with local microwave links has been studied. Sidelobe levels specified for the radar will preclude such interference. Both TV and AM/FM home entertainment receivers should not be seriously affected. As stated in Attachment 3 of Appendix V, 95% of the TV receivers at a distance of about 1.5 miles should not experience detectable interference due to receiver saturation or high power effect. According to ECAC analysis, however, TV receivers tuned to channel 9, 10 or 11 could

experience a spurious response due to PAVE PAWS sidelobe radiation. The signal strength that will be experienced at Sagamore and Sandwich, which are within the 240^{o} radiation sector, is expected to be extremely small due to the elevation of the PAVE PAWS site and to the radio frequency attenuation afforded by the trees, underbrush and natural terrain of the area. For those TV sets that are affected by the radar, a corrective action will be taken by installation of a small, inexpensive filter trap on each set which will completely eliminate the problem. The precedent for this type action has been set at the AN/FPS-49 radar at Morristown, NJ. Filters were installed in affected TV and home entertainment receivers.

FM mobile equipment installed on vehicles and ships outside the base is listed on page 4, attachment 1 of Appendix V. These equipments should not experience any interference since they operate outside the base and at frequencies that will not be affected by PAVE PAWS radiation.

Electromagnetic interference (EMI) effects are not serious and are discussed in Appendix V, attachment 3.

In order to assure that EMR effects are minimized and that specification requirements are met, on-site verification must be accomplished by the contractor. The contractor will initiate and complete all corrective action and fixes should the PAWS, due to design deficiency, cause interference to other equipments outside the facility. If no design deficiency exists and the PAWS interferes with external equipment, the contractor will participate with the government in determining the cause of the problem and proposing a solution. Implementation of the solution will be the responsibility of the government.

b. Effects on Energy Supply and Natural Resources Development.

(1) Non-renewable Energy Sources - The consumption of fuel oil for PAVE PAWS power generation at Otis will increase the drain on non-renewable oil resources by approximately 300 gallons per hour; however, the shutdown of the AN/FSS-7 radar system will cause a compensating reduction of 40 gallons of fuel oil per hour per site, or a total of 80 gallons per hour on the east coast.

(?) Vegetation, Wildlife, Marine Life - Trees and shrubbery will e removed from the four acres required for construction of buildings ard pavement. In addition, the access road will require the clearing of a 40 foot wide strip of vegetation wherever encountered along its length. The road may follow the present alignment of some of the existing dirt roads for part of its length, which will reduce the amount of clearing involved. However, it is likely that 5 or 6 acres of vegetation will be removed for the access road. The existing vegetation will be preserved in the remainder of the acreage surrounding the radar site. Wildlife will be forced to relocate from the areas cleared of vegetation, and the larger animals will be excluded from the radiation hazard zone by the installation of fencing. Birds will continue to use the forested areas surrounding the radar installation, and very likely will fly through the biological hazard zone. Since the radar beam will not dwell at any spot for more than a fraction of a second, the possibility of an energy accumulation sufficient to cause tissue damage in wildlife is slight. There has been no evidence of deleterious effects to birds and animals at similar existing radar installations. An impact to marine life is not expected since all streams, ponds, canals and bays are further than one and a half miles from Flatrock Hill, and there are no interconnecting drainage courses. The overall impact of PAVE PAWS on the vegetation, wildlife and marine life in the area will :e neglible. Refer to Appendix IV for further discussion of the impact.

(3) Renewable Natural Resources - The project will not significantly impair nor enhance the quality of renewable natural resources in the area. About ten acres of land will be cleared of vegetation, and developed as a radar site and access road, thus preventing the natural vegetation from reestablishing itself in that area during the life of the radar system. The remaining uncleared areas will continue growing, unaffected by PAVE PAWS. Water used for the new installation will be treated as necessary and returned to the soil for natural recycling.

(4) Soil Quality - The quality of the soil in the vicinity of the radar site will remain unchanged except for slight contamination from storm drainage runoff from roads and parking surfaces. The quantity of salts, oils, pesticides, etc. washed from the pavements should be minor. There is also a possibility of oil spillage at the fuel storage tanks for the diesel power plants. Normal use of the storage facilities will not involve oil spillage, but in the event of accident, emergency oil spillage plans will be implemented to minimize the damage to the environment. Such plans could require the complete removal of all contaminated surface material following the accident.

(5) Food Resources - There are no farms or food storage facilities in the proximity of the radar installation, therefore, contamination or deterioration of food for human consumption is not a consideration. Food for wildlife will be affected only to the extent that the area within the hazard zone will be fenced off, and will no longer be available to larger animals for foraging. The ten acres of cleared land will be almost completely useless to wildlife as a food source. In view of the thousands

of acres of undisturbed forest surrounding the radar site, the impact of PAVE PAWS on the food supply for wildlife is negligible.

c. Effects on Land Use and Land Management.

(1) Existing Character/Future Development - The installation of PAVE PAWS will affect the existing character of the land by converting ten acres of natural woodland to a developed area containing a multistory radar structure, power plant and pavements. Although the change is significant to those ten acres, the overall character of the surrounding region will remain as before, - a 3,000 acre wildlife management area within a military reservation, which is also used by the Army National Guard as an artillery firing range. Some of the firing range activity will be relocated from the vicinity of the radar. The aesthetic quality of the woodland will be changed by the addition of the radar building which will be visible from any high point affording a view of that area. The impact of this scenic change will be lessened by its distance from public viewing locations, (3500 feet minimum), and by the simple architectural treatment of the structure. Future development of the military reservation in the vicinity of the radar will be prevented during the life of the system.

(2) Public Service Facilities and Utilities - The radar operating and maintenance personnel and their familites will live in existing quarters on-base, as well as in the adjacent communities. The added number of people who will reside in the nearby towns and who will use the existing public service facilities and utilities are provided in the socio-economic discussion in paragraph 3.c.(4).

In general, the increased use of these facilities should cause no problem, since there has been a recent decline in population at and around Otis resulting from military cutbacks. In 1972, there were 4788 full time personnel at Otis, (11,245 including dependents), whereas that figure has decreased to 1204 in 1975.[3]

PAVE PAWS would reverse the trend somewhat, but would not impose the same magnitude of load on public services that had prevailed prior to the cutbacks. As mentioned in 1.b (10), there are 14 empty classrooms in the Bourne School System. The Superintendent of Schools in Bourne has indicated that the present facilities would accommodate the additional pupil load resulting from PAVE PAWS with ease. The Coast Guard Clinic presently in operation at Otis, in conjunction with the hospitals in Falmouth and Pocasset, as well as the Bourne Public Health Service, should be adequate to handle the needs of the population increase resulting from PAVE PAWS.

The radar site will have its own water storage, fire pumps, hydrants, sprinkler and alarm systems. However, an arrangement will have to be made with the fire departments at Otis AFB and in the neighboring towns to provide additional fire protection. Discussion with the Chief of the Otis AFB Fire Department confirms that there are existing mutual support agreements with the surrounding towns which can be expanded to include fire protection service for the new radar installation. The towns of Sandwich and Bourne have hook and ladder units which are capable of reaching the full height of the radar building.

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Separate access to the Flatrock Hill area of Otis will be provided from Route 6W, northwest of the site. In addition to providing access to the radar site, this route will also serve as an improved entrance to the northern portion of the base in fighting the occasional forest fires which occur in that area.

The impact of this project on the local Police and Highway Departments should be minimal, and certainly not as significant as in the period prior to the latest military cutbacks in 1973.

(3) Master Plans - There is no known conflict with military approved master plans, programs and regulatory controls at Otis AFB.

(4) Private Facilities and Operations - As mentioned above, the 1973 cutbacks in the military activity at Otis created a situation where there was excess capability in many of the facilities in and around the reservation - both public and private. Shopping centers, housing, transportation and recreation facilities in the adjacent towns should be able to accommodate the needs of the PAVE PAWS population increase with little difficulty. The radar project will involve several million dollars in construction and installation costs over a three year period, and approximately two and a half million dollars a year in federal payroll when the radar becomes operational. In addition, there will be an increase in community employment to provide the goods and services required for the radar and its operating personnel with their families. An estimate of the economic benefits is tabulated below for the alternate radar manning schemes which are being considered. The PAVE PAWS will either

be manned completely by military/government service personnel (blue suit) or by a military/government service cadre with contractor support. The decision will be made by Hq USAF prior to contract award.

The following estimate shows the anticipated increases in jobs, residents and wages/salaries, both at Otis and in the neighboring towns, for each alternate manning plan.*

	Blue Suit	Contractor Support
Otis Employment	248 **	173 ***
Otis Wages & Salaries	$2,689,418	$2,288,928
Otis Residents	710	245
Community Employment	205	209
Community Wages & Salaries	$1,597,347	$1,757,451
Community Residents	875	1092

* Rate factors used to quantify effects are listed in p. 1 of Appendix VI-B

** Blue Suit Manning consists of 22 officers, 181 airmen & 45 Government Service.

*** Contractor Support Manning consists of 12 officers, 58 airmen, 13 Government Service and 90 Contractor support.

This economic gain to the Cape will be offset by an economic loss in the areas near Charleston AFS, ME, and Fort Fisher, NC, of about $1,000,000 per year in federal payroll for each site, due to the shutdown of the AN/FSS-7 radar system. Refer to Appendix VI for details of this action.

Appendix VI contains an ADCOM assessment of the eventual phasedown of six AN/FSS-7 SLBM Detection Radars. The assessment also addresses the subsequent phasedown of Long Range Radars (LRR) collocated at these stations.

The LRR's will either be phased out or turned over to the Federal Aviation Agency (FAA) for use in the Joint Surveillance System (JSS). Only that data applicable to the phasedown of the AN/FSS-7 functions at Fort Fisher AFS, NC and Charleston AFS, ME are relevent to this assessment since the phasedown at those sites is directly coupled to implementation of the east coast PAVE PAWS. The AN/FSS phasedown at McDill AFB will not be addressed. This station is beyond PAVE PAWS coverage, and the phasedown is a separate action not PAVE PAWS dependent.

The AN/FSS-7 phasedown at Mt Hebo AFS, OR; Mill Valley AFS, CA; and Mt Laguna AFS, CA,will be discussed in the west coast PAVE PAWS Assessment. Although the phasedown of the LRR's collocated at Charleston and Ft Fisher is an Air Force action unrelated to PAVE PAWS, the combined economic effects of both actions are included in Appendix VI to show the total impact to the surrounding communities within the next few years.

Shown below is a tabulation of the AN/FSS-7 phasedown effects applicable to both Ft Fisher and Charleston. This data has been drawn from Appendix VI. The effects shown include decreases in employment and annual wages and salaries both on station and in the community. The total number of station and local employees and dependents affected is also indicated.

Station Employment	- 76
Station Wages & Salaries	- $1,080,992
Local Employment	- 54
Local Wages & Salaries	- $ 563,579
Station/Local Residents	- 455

The resulting local effects are estimated at approximately 1% of population, employment and wages at Charleston AFS, ME and less than 1% at Ft Fisher AFS, NC. This is not considered a major impact to these communities.

The combined AN/FSS-7 and LRR phasedown effects are approximately 2.5% and 2.0% at Charleston and Ft Fisher respectively, which constitute noticeable but not significantly adverse socio-economic impacts at those locations.

(5) Standards of Design - Appropriate federal, state and local design standards will be observed in the development of the radar site, to provide high quality permanent facilities which are architecturally in consonance with the aesthetic values of the surrounding wildlife area.

(6) Historical Sites, Parks - The only nearby park is the Shawme - Crowell State Forest on the far side of Route 6 from the military reservation. It is no closer than 3600 feet from Flatrock Hill, which is sufficient distance to avoid any significant impact from the proposed radar. Due to the dense growth of vegetation in the State Forest, it is doubtful that the new radar will be visible from there.

There are many historical features in the communities adjacent to Otis but none at the Flatrock Hill location. The only impact to the off-base historical sites which might result from the PAVE PAWS project, would be an increase in highway congestion. From 100 to 200 vehicles per day would travel to and from the radar site, using Routes 6W, 6, 28 and 130 which connect to the other gates at Otis and to shopping and residential areas in the vicinity. This is not considered to be a significant impact to the flow of tourist traffic visiting the various historic locations in the area.

(7) Archeological Resources - This part of the Cape is the ancestral home of the Wampanoag Indians, and various artifacts have been found occasionally in and around the military reservation (see Appendix IV). Contact will be maintained with the State and local organizations interested in the preservation of any such artifacts which may be discovered during the development of the radar site.

An alternate design using a higher frequency (L-Band) is technically feasible but would be more costly and would require greater radiated power resulting in a larger impact to the environment in the areas of radiation effects, EMI and fuel consumption. The contractor is also permitted to vary the waveform, the duty cycle and even the total site energy concept as long as the performance requirements are upheld. Needless to say, he will be restricted in his design to provide a system that minimizes the environmental impact. This is a criterion that will be scrutinized closely when the technical evaluation of contractor proposals is in process. The Phased Array type radar emits a short (in the order of 2 milliseconds) high powered pulse of energy. During the period the transmitter is off, the receiver is on and the return signal is received by the radar. The receiver is then shut off when the brief transmit pulse is sent out again. Because it is a pulsed system, (as opposed to a continuous wave system), the average transmitted power is lower, and consequently the radiation hazards are less.

e. Different Locations. Many locations in the Northeast CONUS were considered as potential sites for the PAVE PAWS Phased Array Warning System. The Northeast was picked because it provided the optimum coverage of the threat area in the Atlantic and surrounding waters, given the specific geography of the North American continent and the technical characteristics of the phased array radars. In the interests of economy and minimal environmental impact, first priority for a site location was given to existing DOD property. Further, a thorough coverage analysis determined that the site should be located within a 150 NM radius of central Massachusetts to maximize radar coverage

and maintain the requirement that the site be located on the periphery of the CONUS. The periphery criterion was evolved from SALT.

In selecting candidate locations for the PAVE PAWS facility, specific criteria were used in addition to the siting criteria mentioned above. Consideration was given to environmental factors, population densities, other radar/electronics facilities, airports/runways, transportation routes, suitability of terrain, proximity of support facilities and socio-economic impacts. Each of these criteria was evaluated against the following sites which were selected for consideration.

Charleston AFS, ME

St. Albans AFS, VT

Pease AFB, NH

NH Satellite Tracking Station, NH

Montauk AFS, NY

Ft. Devens, MA

Natick Labs (Army), MA

Westover AFB, MA

Otis AFB, MA

North Truro AFS, MA

Of all the criteria used, the one which most heavily impacted site selection was availability of sufficient land with the "look angle" required. The land factor was critical because of the electromagnetic radiation hazard criteria which are quite stringent and are explained in detail in Appendix V. The clearances required around the facility arepredicated on the "worst case" design factors. The land required for the PAVE PAWS site consists of

about 4 acres for a technical facility, 6 acres for an access road, plus a buffer zone of approximately 1000 ft radius extending in the direction of the radiation. This dictates a land area of about 50 acres. Only three of the sites surveyed had this amount of acreage located far enough away from the main part of the installation to avoid interference or radiation hazard risks. These sites were Westover AFB, Otis AFB and North Truro AFS. The Westover facility was discounted because it was too close to a population center, had blockage of the horizon, and would cause unacceptable electromagnetic compatibility problems. The North Truro site is considered a viable option, but because it is very close to a National Park, the risk of violating environmental objectives was considered high. Further, the distance from the nearest support base and the cost of augmenting power facilities at Truro were felt to be negative factors. It is interesting to note that Truro is the one site that does not have the minimum land acreage available but is able to take advantage of the fact that it is located on the shore and much of the hazard buffer zone extends out over the water. Additionally, the site is situated on a high cliff, thus elevating it above the surrounding terrain.

A comprehensive and detailed survey and analysis revealed that the Otis AFB site was the only site which could meet all of the criteria . Because of the large land acreage available at Otis, (22,000 acres), it was possible to find a site which could be built and contained totally within the confines of the base. However, as with all the other sites, there were some disadvantages. The principle disadvantage of the Otis site is that it impacts some of the facilities located within the installation. These include infringement on the artillery range, and interference with aircraft

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flight patterns. Initially two potential site locations were identified, Pine Hill and Deer Horn Hill.

Selection of Pine Hill, the more desirable of the two, was strongly opposed by the Mass. Army National Guard. Its selection would have restricted access to the northern area of the range, would have interfered with the flight corridor used by range observation aircraft, and would have required a major relocation of and reduction in artillery firing positions. Relocating a small arms range would also have been required. The impact of these actions would have been significant to the operational value and tactical utilization of this property, possibly reducing its usefullness to the point that the National Guard units throughout New England would find it more advantageous to use Camp Drum in New York for their training exercises. This is an eventuality which the Adjutant General of Massachusetts and the Governor's Office were anxious to avoid because of the economic impact to the state. Additionally, a radar at Pine Hill would have interfered with flight activities on Runway 14, since EED separation distances for EED equipped aircraft in the "wheels down" configuration would have prevented these aircraft from use of the final approach to that runway.

Deer Horn Hill was acceptable to the National Guard but later abandoned because of its close proximity to base housing and potential conflict with the proposed Veterans Administration National Cemetery.

Hill 280 was considered as a possible alternative, and was found to be acceptable in most respects. However, it involved the relocation of a 115KV commercial power transmission line, and conflicted with National Guard activities more extensively than at nearby Flatrock Hill.

Further discussions with the National Guard and additional field surveys at Otis, resulted in the selection of Flatrock Hill. This is considered an optimum location, minimizing interference with both the artillery range and flight patterns. Although the site is closer to the reservation perimeter than Pine Hill, infringement on the surrounding community is controllable and/or resolvable. Flatrock Hill represents a compromise acceptable to all.

As a result of the detailed site analysis, the number of candidate sites for the PAVE PAWS East Coast Facility was reduced to two, Otis AFB and Truro AFS, both on Cape Cod, MA. Otis is considered the better candidate due to the larger land mass available, the proximity of electric power and services, and less impact on the environment external to the DOD property.

The site selection process for the PAVE PAWS East Coast Site extended over a period of 18 months. The site ultimately selected, Flatrock Hill at Otis AFB, presents the least impact to the surrounding environment of all locations considered.

PAVE PAWS is a defensive warning sensor with little or no strategic value. A strike on a warning sensor would be warning in itself. Therefore, while the Otis area as a target would increase in priority, the degree would be limited.

5. Probable Adverse Environmental Effects Which Cannot be Avoided.

Most of the environmental effects resulting from the PAVE PAWS program cannot be avoided, however the adverse effects can be minimized by proper planning, siting, design and installation of the radar system. For example:

a. The effluent from the sewage system and other drainage systems will be treated to meet federal, state and local water quality standards.

b. The power plant will be designed to conform with federal, state and local air quality and noise suppression standards.

c. The adverse effects from electro-magnetic emanations will be kept to a minimum by siting the radar in a remote location contained within a government reservation, away from population centers, parks, historical sites, transportation routes, and other systems and equipments. Frequency management and guard bands will be employed to minimize interference with other systems. Hazard areas will be fenced and posted with warning signs. The use of electro-explosives off-base will be controlled by town permit procedures.

d. Cleared areas will be replanted, graded and stabilized as required to prevent erosion and to restore the aesthetic quality of the region.

e. Construction techniques will be employed to control the generation of dust.

f. Water obtained from wells will be used, treated and returned to the earth to replenish the ground water table.

g. The radar design will be developed at the lower range of possible power needs, to minimize energy use and radiation effects. The low energy requirement will result in the least possible fuel consumption.

6. Relationship Between Local Short-Term Use of Man's Environment and The Maintenance and Enhancement of Long-Term Productivity.

The most consistent and probable long-term use of the land in the area of the PAVE PAWS radar is as a conservation area. Most of Otis Air Force Base (about 17,000 of the 21,000 acres) is in its natural state and constitutes the largest remaining undeveloped Cape Cod area. As such, it is suitable for, and supports, a varied wildlife population including a herd of white-

4. Alternatives

The following alternative actions were considered.

a. Take No Action. The alternative of not building the PAVE PAWS SLBM detection and warning system has been explored in depth over the last several years. The issues of mission requirements, environmental impact, system benefits, technical limitations and current capabilities have all been carefully examined. The PAVE PAWS technology is based upon proven phased array radar techniques whereby objects the size of current sea launched ballistic missiles can be detected at ranges exceeding 2500 nautical miles. Ground based SLBM systems in operation today are far inferior to this capability and are unable to meet the needs of today's mission. "No Action" on the PAVE PAWS system would force continued dependence on the present inadequate systems. The phased array technology is particularly suited to the SLBM detection mission. Conventional radars can not economically provide the coverage required nor can they manage to achieve the number of targets and tracking accuracies at the extended range demanded of today's systems. "No action" at this time would seriously limit the ground based detection and warning capability of the United States National Command authority particularly in view of the present SLBM threat.

b. Postpone Action Until A Later Date. The implementation of this system is already over-due in view of the presence of today's long range SLBM threat. Postponement of this system for a year or two would result in unacceptable risks in that no presently operational ground based detection systems would be able to provide the warning times required for strategic forces nor would attack characterization data acquisition be achievable in the event of a hostile missile attack from the sea.

The technology to provide the warning system is available, the threat is real, therefore, postponement would serve no useful purpose and will seriously hinder the national defense posture. In addition, the current hostile attitudes presented to the United States by various countries where U.S. radars are in operation, seriously impede our Spacetrack mission. Although Spacetrack capabilities are a secondary function of PAVE PAWS, they will have added importance if our present radar capabilities are curtailed in those countries.

c. Implement a Different Approach. There are no other known technologies that could accomplish the same results. The size and complexity of these systems preclude the use of an airborne platform to provide the needed warning and attack characterization accuracies. The use of a conventional parabolic radar is not feasible because it cannot perform the scan while track function, it will not reduce the transmit power levels and cannot perform multiple tracking, a prime requisite of the PAVE PAWS system. The most economical means of performing the SLBM detection mission is with a ground based phased array radar system.

d. Same Action - Different Design. Given that the system is to be a phased array radar, there are several variables in the design which can be employed. The firms bidding on this project have been given latitude to implement a design which meets performance specifications but may employ significant technical differences. One of the most important variances allowed is the area of frequency band selection. The radar frequency selected for PAVE PAWS is in the UHF band, which has certain inherent advantages over higher frequencies, such as requiring less radiated peak power, lending itself to the use of solid state modules for the transmitter elements and resulting in a less costly system.

tail deer and various other mammal and bird species. The proposed Flatrock Hill site is within the 3,000 acre Otis Wildlife Management area; to the west of the site is a migratory corridor linking the area to the Crane Wildlife Management area south of the base; and to the north, beyond the northern perimeter of the base, is the Shawme Crowell State Forest. In addition to the continuing conservation function, other proposed future uses of the area envision utilization and preservatinn of the natural state and serenity of the locale; suggested future uses have included recreational use, a Visitor Center for the Cape Cod area, and a Veterans Administration Cemetary. A continued state policy of restricting development or commercial incursion into the area can be anticipated.

The projected PAVE PAWS Radar is planned to have as little impact on the future environmental function and productivity as possible. The construction phase to install buildings, equipment, and necessary utilities will create some disturbance in the area with accompanying dust, noise levels, and minor vehicle pollution, within existing ambient air quality standards. Wildlife in the area have become accustomed to noises due to prior use as a firing range and impact area. Wildlife cover, forage, and migratory corridors should be minimally impacted during constructinn due to the vastness of the total area. Some vegetation clearing and grading will effect minor land modification within the area of the project and its access road (about ten acres). During the projected ten year operational lifetime of the facility, a surrounding game exclusion fence will enclose a larger area, estimated at approximately 50 acres. This area will not be otherwise disturbed and will retain its natural characteristics. Standard practices and regulations con-

cerning treatment and disposal of effluents, noise abatement, erosion control, and other environmental requirements will be complied with. Radiation hazards from the radar beam will not affect wildlife due to beam elevation above ground level and the protective fence. Birds may fly into the radar beam, but the low exposure time during rapid beam sweep, and experience with other similar but more powerful emitters, suggests that they will not be harmed.

The presence of the radar site may indirectly contribute to enhancement of the indigenous forest region through stabilizing of the area activity. At present forest fires occur occasionally in the area due to detonations and stray rounds in the Army firing range. The ravaged areas are colonized rapidly by pitch pine growth which is acceptable, but less desirable than other species. Good forest management practices could probably be put into effect in the surrounding area, such as periodic replacement of the pitch pine with other species such as white pine. This would have the long-term beneficial effects of reducing fire hazards, producing a superior wildlife habitat, and creating a more generally aesthetic and productive forest area.

7. Irreversible and Irretrievable Commitments of Natural Resources.

a. The fossil fuels required to generate power for this project will be an irretrievable commitment of natural resources. Also the small quantities of cement, sand and gravel used to produce concrete for the building

foundations (about 700 GY) will not be retrievable.

b. No other significant commitments of natural resources resulting from the implementation of the PAVE PAWS program are irreversible or irretrievable.

8. Considerations that Offset the Adverse Environmental Effects.

a. Any adverse environmental effects, such as fossil fuel depletion, air, noise, and water pollution, establishment of a restricted space for air traffic, highway usage, additional demands on community services, aesthetic intrusion, wildlife disruption and interference with other electronic systems, are offset by the much needed attainment of an improved capability for early detection and warning of SLBM launches against the United States.

b. An additional consideration is the diminishing of the present adverse environmental effects associated with the operation of radars at Charleston AFS, and Ft Fisher AFS, when those radars are closed down upon completion of the PAVE PAWS installation.

c. Further, the Cape Cod economy will benefit from the funds spent to install and to operate the PAVE PAWS system. This benefit, in turn, is partially offset by the economic loss which will occur near Charleston AFS and Ft Fisher AFS when the AN/FSS-7 radars are removed.

9. Details of Unresolved Controversies.

a. The controversy over the proposed use of land within the Army National Guard firing range at Otis for the PAVE PAWS radar, has been settled to the mutual satisfaction of the Air Force and the State Adjutant General by relocating the radar from the Pine Hill area to Flatrock Hill.

Final details of the proposed radar installation at Flatrock Hill remain to be coordinated with the Adjutant General, to assure the least measure of interference between the two agencies in conducting their respective activities in that part of the reservation.

b. The USAF School of Aerospace Medicine, Brooks AFB, Texas, has conducted a test program to further investigate the biological effects of electromagnetic radiation. It has submitted for publication, its latest findings in AFR 161-42, Radar Frequency Radiation Health Hazard Control, in which 10 mw per cm^2 is the hazard criterion for 6 minutes or greater. Exposures of less than 6 minutes are subject to a criterion of 3600 mw sec per cm^2 allowing for greater exposure to radiation for shorter periods of time. For example, exposure for one minute allows a power density of 3600/60 = 60 mw per cm^2. These effects are not cumulative. Illumination on the ground from the radar is assumed to be continuous since it is created by sidelobes which extend in many directions from the main beam. See Figure 1 and 2, Appendix V. Illumination in the air due to the main beam is of very short duration (100 milliseconds) and will not "hit" any object more than once every few seconds. An exclusion fence installed at a radius of about 1000 ft. from the radar in the sector of radiation will prevent personnel and wildlife from entering the biological hazard zone (Figures 7 and 8, Appendix I) Objects in the air such as birds or aircraft will not receive enough radiation for a sufficient period of time to be considered harmful, due to the sporadic nature of the beam. Also, an aircraft with metal skin offers additional shielding to the passengers. Scientists in the Soviet Union have advocated a value of 1 mw/cm^2 for biological effects and, although this criterion has not been corroborated by U.S.

scientists, it has become a matter of concern and additional study is in progress both in the U.S. and the Soviet Union. The criteria stated in AFR 161-42 have been approved by the Air Force and are reputed to be the best information available.

c. Interference with TV channel 10 emanating from Providence, R.I. is a theoretical possibility, and if it occurs, will be handled by installation of an inexpensive filter trap at each affected antenna. The trap would filter out the unwanted transmission from PAVE PAWS and would not affect the normal signal from channel 10. At the Flatrock Hill location, it is estimated that approximately 700 TV sets are used within the 2.4 mile radius of possible PAVE PAWS influence from the baseline system. About 1700 TV sets are used within the 4.8 mile radius of influence considering system growth. Of these sets, approximately 50% might be susceptible to the radar signal. This theoretical possibility can be considered to be an unresolved controversial issue pending field results during operation of the radar.

d. Limitations imposed on the use of EED's in Sagamore and Sandwich could lead to controversy, however, no such opposition was suggested during preliminary contact with those communities. Alternate acceptable means for detonating explosives are readily available, however, the use of explosives in those towns is rare and is controlled by permit.

e. Although other local objections to the installation of PAVE PAWS may arise, there are no known controversies at this time. The likelihood of local objection is lessened by the fact that the radar is sited well within the boundaries of a military reservation with minimum impact anticipated to

the adjacent communities.

10. Appendices.

a. Appendix I

Figure 1 - Artists Concept of Radar Site

Figure 2 - Otis AFB - Site Locations

Figure 3 - Topography at Flatrock Hill and Hill 280

Figure 4 - Topography at Pine Hill

Figure 5 - Topography at Deer Horn Hill

Figure 6 - Population Density

Figure 7 - Radiation Hazard Distances - Baseline

Figure 8 - Radiation Hazard Distances - Growth

b. Appendix II Site Survey Reports

c. Appendix III

Table 1 - Sources of Personal Income

Table 2 - Comparative Site Ratings

Table 3 - Distances from Population Centers

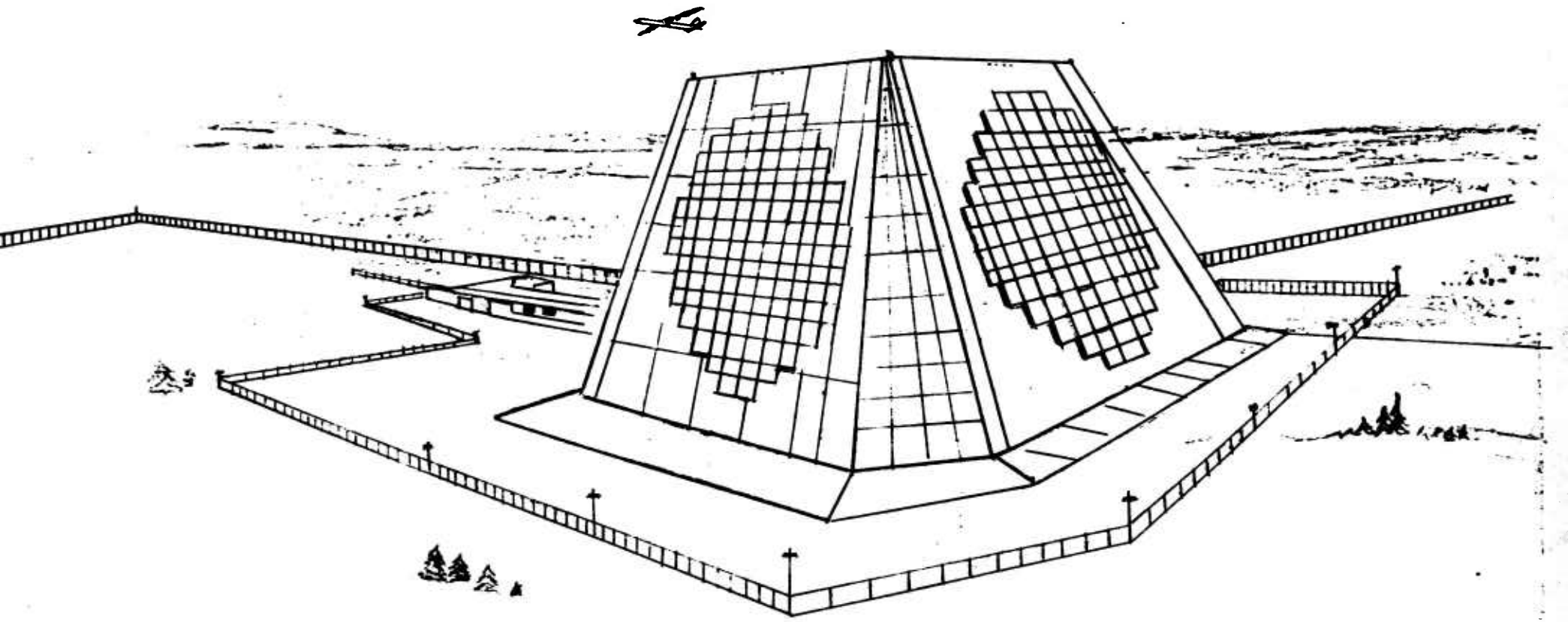
d. Appendix IV Ecological Survey Report

e. Appendix V Electromagnetic Radiation Report for PAVE PAWS

f. Appendix VI ADC Assessment of AN/FSS-7 Phasedown

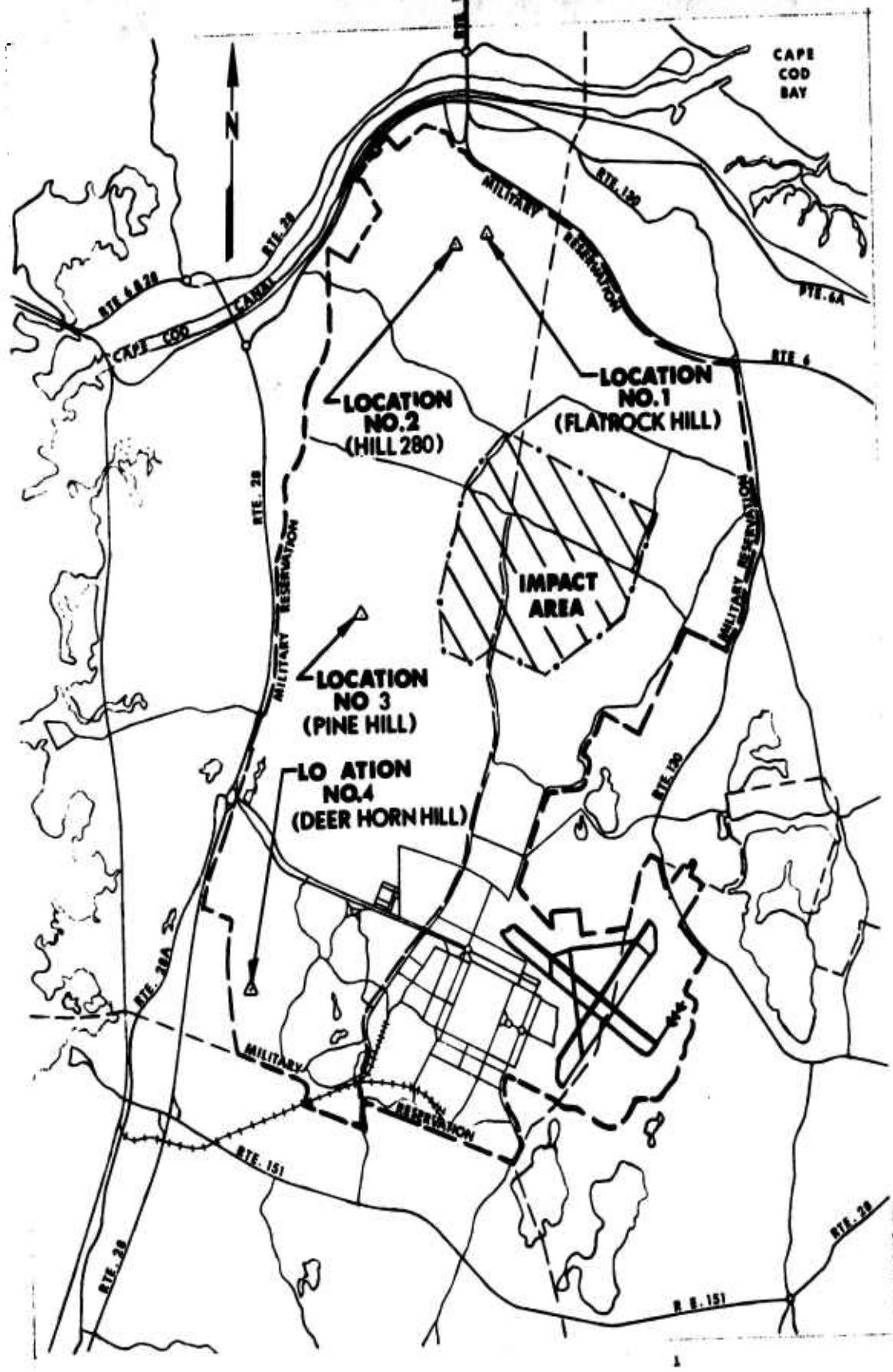
g. Appendix VII - USAF School of Aerospace Medicine Clarifications

PAVE PAWS

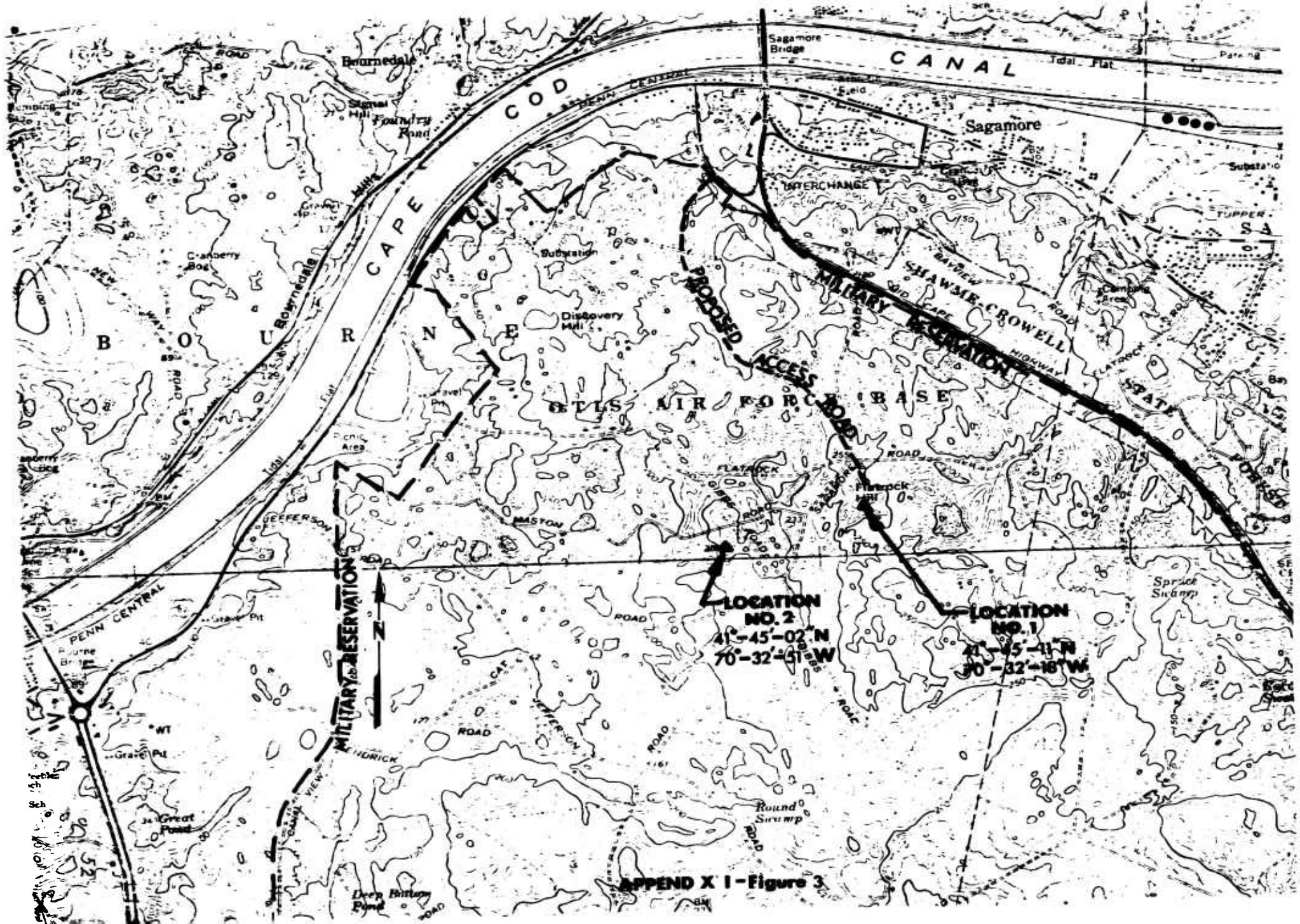


APPENDIX I – Figure 1

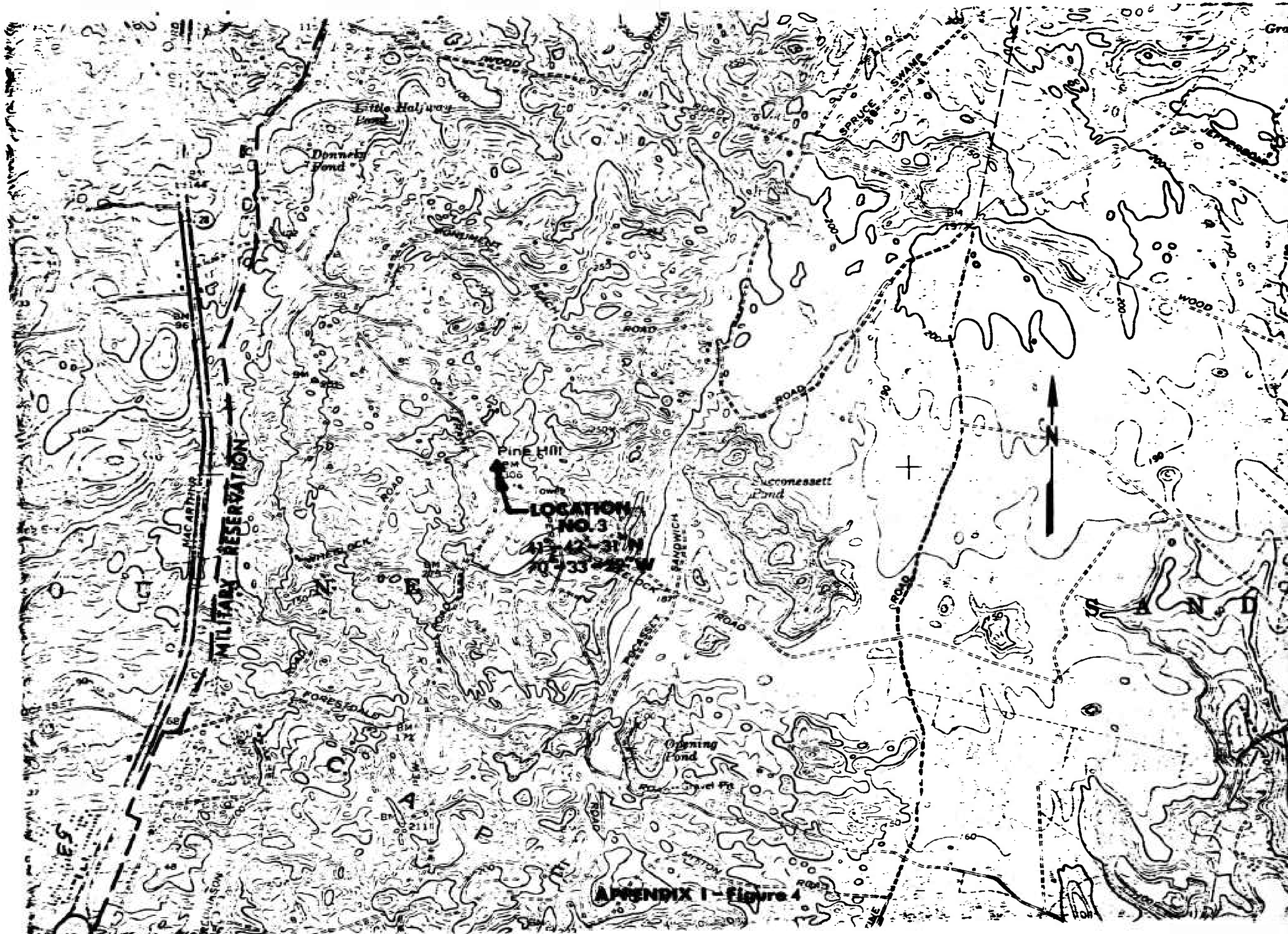
APPENDIX I



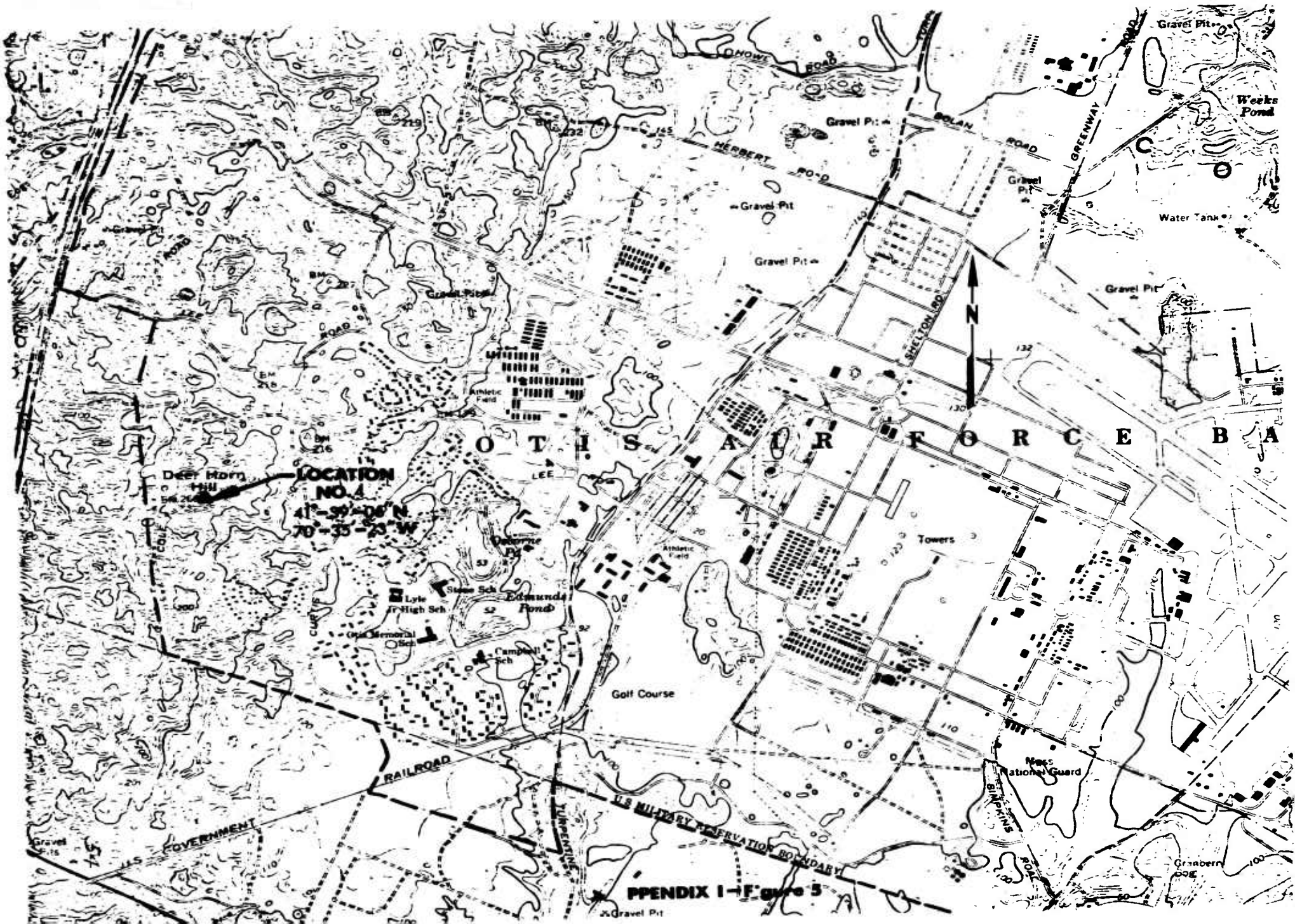
APPENDI I — Figure 2



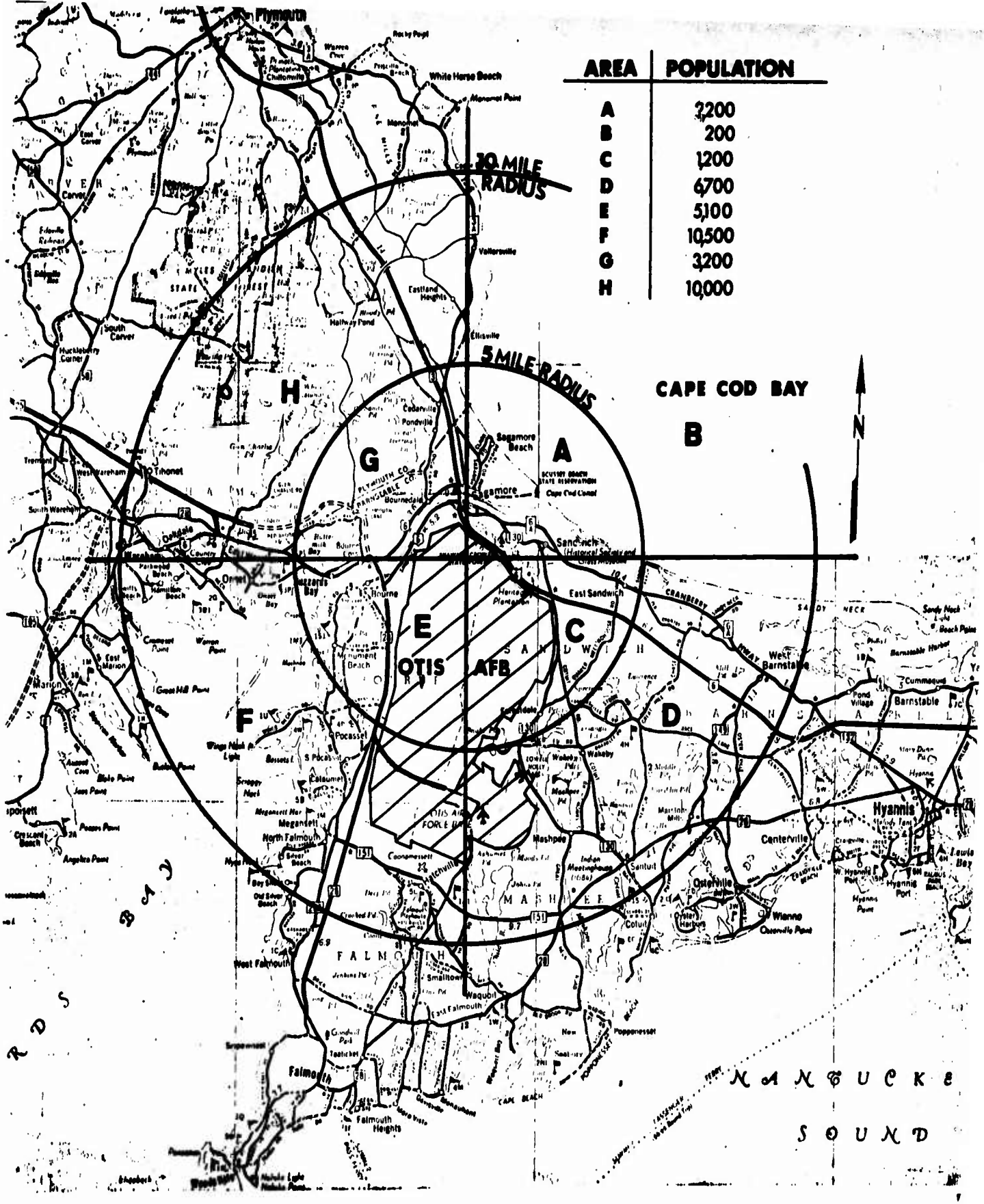
APPEND X I - Figure 3



APPENDIX I - Figure 4



APPENDIX I – Figure 5

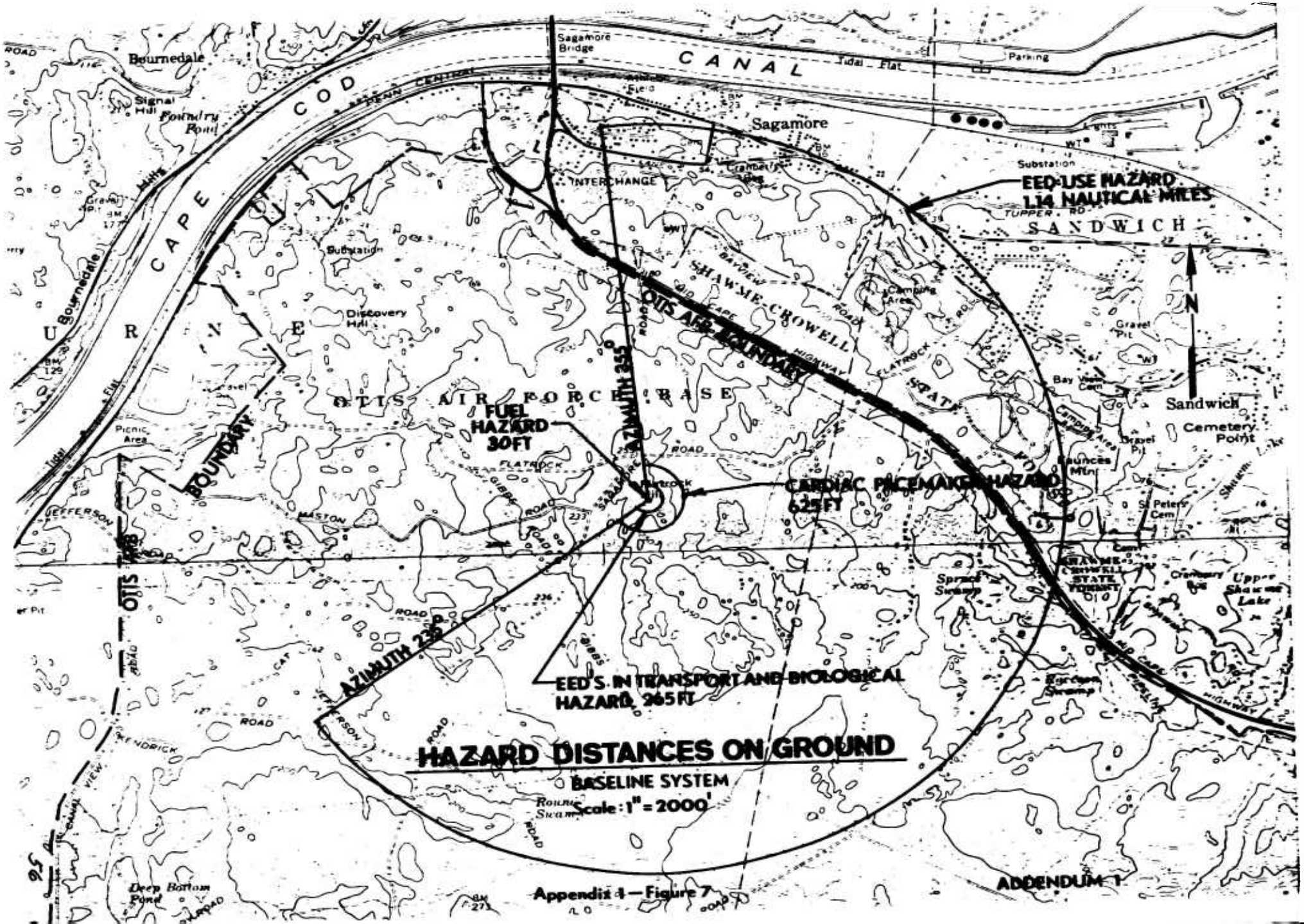


POPULATION DENSITY

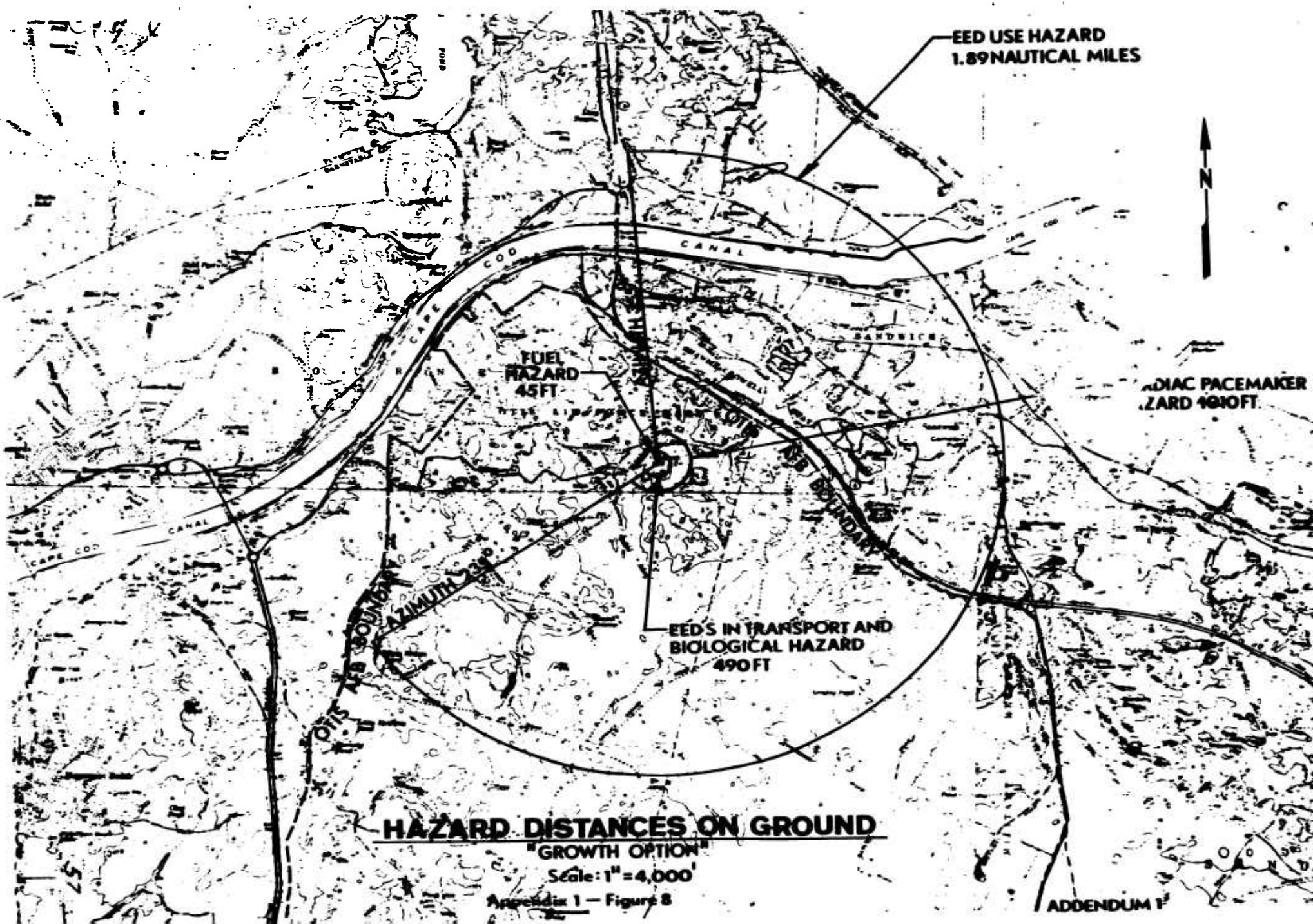
NEAR OTIS AFB

(AT 5 AND 10 MILE RADIUS FROM FLATROCK HILL)

APPENDIX I — Figure 6



Appendix 4 — Figure 7



HAZARD DISTANCES ON GROUND

"GROWTH OPTION"

Scale: 1" = 4,000'

Appendix 1 — Figure 8

APPENDIX II

SITE SURVEY REPORT FOR NORTHEAST
SITE LOCATION, NOVEMBER 1973

SITE SURVEY REPORT FOR EAST COAST
LOCATION, MARCH 1975

SITE SURVEY - OTIS AFB, 28 JULY 1975

SLBM PHASED ARRAY RADAR SYSTEM

(SPARS)

SITE SURVEY REPORT

FOR

NORTHEAST SITE LOCATION

NOVEMBER 1973

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 Purpose. This report covers the site surveys conducted by ESD to select the most suitable location for the Northeast SPARS Site.

1.2 Authority.

1.2.1 AFSC Form 56, 2059-1-74-12, dated 20 September 1973, Coastal Defense Radar System.

2.0 BACKGROUND

2.1 For a description of the radar system refer to AFSC/ESD Program Management Plan (PMP) for SLBM Phased Array Radar System (SPARS), 20 September 1973.

2.2 The initial siting effort was devoted to the gathering of topographic maps, aeronautical charts, lists of existing DOD properties, and to the development of siting criteria to be used in the selection of a SPARS radar site.

2.3 In compiling a list of DOD properties, queries were directed to the real estate office of the U.S. Army Corps of Engineers, New York District, and New England Division, and to the real estate office of AFSC. Several miscellaneous parcels of excess land were identified by the Corps of Engineers, but no overall listing of existing DOD properties was available. AFM 87-13, USAF Installation Directory (Worldwide), was used as a reference for selecting AF properties.

2.4 The choice was limited to an area within a radius of approximately one hundred and fifty miles from Boston, MA, for the most effective geographic radar coverage. Within this area, the following candidate sites were selected for consideration. (See Appendix I)

2.4.1 Otis AFB, MA

2.4.2 No. Truro AFS, MA

2.4.3 Montauk AFS, MA

2.4.4 Westover AFB, MA

2.4.5 Natick Laboratories, Sudbury Annex, MA

2.4.6 Pease AFB, NH

ABSTRACT

Site surveys consisting of desk studies and a field visit have been performed in the New England area in the past several months to determine a suitable location for the Northeast SPARS Site. The surveys have been limited to existing DOD properties in accordance with AFSC direction.

The results of these surveys indicate that North Truro AFS is the most suitable location for the Northeast SPARS Site.

2.4.7 Ft Devens, MA

2.4.8 N. H. Satellite Tracking Station, NH

2.4.9 Charleston AFS, ME (beyond 150 miles)

2.5 Of the sites listed above, 2.4.5, 2.4.6, 2.4.7 and 2.4.8 were eliminated for noncompatibility with present use and/or density of population in front of the proposed radar. Site 2.4.1 and 2.4.4 were disapproved by USAF/PRPO in line with recent DOD action to curtail AF activity at those bases. Site 2.4.9 is outside the geographic area of primary interest, and was listed only as an alternate in the event that the other locations are unavailable. The remaining two locations, North Truro AFS and Montauk AFS, were considered suitable for further investigation, with North Truro AFS being preferable from the standpoint of personnel radiation hazard, interference with existing operations, available real estate, topography and air traffic.

2.6 Prior to visiting the candidate location, written authority was obtained from USAF/PRPO in accordance with the requirements of AFR 88-16, and by separate action personnel hazard criteria was reviewed with AMD.

2.7 Site selection criteria used during the map studies are listed below.

2.7.1 Consider existing DOD properties, other federal property, state and municipal properties before investigating privately owned land.

2.7.2 Limit the site studies to within a radius of 150 miles from Boston, MA for the Northeast radar.

2.7.3 The horizon must be unobstructed above 1 1/2^{o} in the scan angle of the radar.

2.7.4 The scan angle of the radar is 240^{o} extending from 355^{o}T to 235^{o}T in azimuth.

2.7.5 The safe distance for radiation hazard to personnel is 150 feet.

2.7.6 The safe distance for radiation hazard to personnel wearing cardiac devices is 800 feet.

2.7.7 The safe distance for fuel hazard is 30 feet.

2.7.8 The safe distance for ordnance hazard is 2,370 feet.

2.7.9 The long range radar building will be about six stories high and will require less than one acre of land for construction.

2.7.10 Consider proximity to airways, airfields, highways, waterways, and railways, and availability of access roads, commercial power, water supply, sewage disposal, communications systems, and other support facilities. Also consider electromagnetic compatibility and cost of site preparation.

2.8 In applying these criteria to North Truro AFS and Montauk AFS it became apparent that North Truro offers fewer problems to the siting of the SPARS. Consequently a field site survey was scheduled for the week of 1 October 1973 at North Truro AFS.

3.0 (U) FIELD SURVEY

3.1 Participants: During the period from 1 October to 3 October 1973, the following personnel participated in the site survey at North Truro AFS.

3.1.1

Lt Col L. Picardat	ADC/XPDS
R. Boldt	ADC/LCXP
A. Libasci	ADC/DEPL
P. Montoya	ADC/DEPR
R. Willats	ECAC/LITRI
P. Koegler	RADC/OCDR
R. Navarro	MITRE
W. Cleven	MITRE
P. Fritsch	MITRE
R. Moore	ESD/OCDR
I. Etkind	ESD/OCDR
L. Blaisdell	ESD/DEE

3.1.2 Contacts at North Truro AFS:

Lt Col R. Prince	C.O.
Maj Mello	Exec & Comm Off
Capt Pickford	Operations Off
2/Lt Anastasia	Support Off
Sgt Ray	GATR Site
T. Henderson	Civ Engr Off

3.2 Performance of Survey.

3.2.1 The survey team inspected the general area proposed for installation of SPARS, and gathered data from the Station Commander and his staff. Very little contact was made with the civilian community since the program is not yet authorized and premature publicity could jeopardize the selection of that location.

3.3 Findings.

3.3.1 Electromagnetic Compatibility (EMC)

3.3.1.1 The major electromagnetic compatibility categories considered in the survey are in-band equipments, adjacent band equipments, harmonically related bands, air traffic patterns and potential high power effects problems. Electromagnetic hazards to personnel, fuel and explosives are discussed in paragraph 3.3.3.

3.3.1.2 The results of the survey indicate that there are three major in-band equipments which could either detect SPAR emissions or whose emissions could be detected by the SPAR receiver. The AN/FPS-35 radar at Montauk Pt, NY, is located 116 miles to the south of North Truro. The two radars may be able to detect each other's emissions and frequency coordination between the two radars may be necessary. A radio telescope is located at Sagamore Hill observatory in Hamilton, MA. Sagamore is approximately 57 miles from North Truor in a generally north-westerly direction. Hence, it will be in the SPAR antenna back-lobe. The radio telescope is a receiver only and so is not a potential source of interference to the SPAR. Because the radio telescope is a very sensitive instrument, it may be capable of detecting SPAR emissions. The third equipment is an AN/FPT-5 ionospheric sounder located at Westford, MA. Westford is 84 miles in a generally northwesterly direction from North Truro. None of the above systems will preclude installation of SPAR at North Truro; however, more detailed analysis should be performed to determine any frequency coordination required between the AN/FPS-35 and SPAR and to accurately assess any problem that may exist between SPAR and the Sagamore Hill radio telescope and the Westford AN/FPT-5 ionospheric sounder.

3.3.1.3 There is an Air Force Ground-Air Transmitter/Receiver (GATR) facility located approximately one mile from the SPAR site. GATR operates in the 225-400 MHz band and utilizes frequencies covering the entire band. Because of its proximity to the SPAR, mutual interference is a distinct possibility. Preliminary calculations indicate that interference to the GATR system will occur when GATR is operating near its upper band edge. The interference should not be sufficiently severe to degrade the GATR performance below a usable level and will occur only at frequencies near the upper band edge. A more detailed analysis is required to further assess the scope of this problem. No other significant adjacent band problems were found.

3.3.1.4 ECAC environmental data files were searched for possible equipments which could respond to SPAR harmonic frequencies. No such equipments were found.

3.3.1.5 High power effects (HPE) interference can occur in equipments located near high powered emitters due to the very high level power densities generated. Television and radio receivers, hi-fidelity systems and many other types of commercial and military equipments are often susceptible to HPE interference. There is little frequency dependence, although most equipments tend to be less susceptible to higher frequency emissions. In the case of this SPAR site, little HPE interference is expected since the radar is located in a remote area and the radar is oriented so that its main scan sector looks out over the ocean. It appears that HPE interference will not be a serious problem for a SPAR located at North Truro.

3.3.1.6 The air traffic patterns in the vicinity of North Truro were examined. There does not appear to be a significant interference potential from a SPAR at North Truro to any known air traffic.

3.3.1.7 North Truro has three radars already in operation. These radars are the AN/FPS-107, the AN/FPS-6 and the AN/FPS-26A. These radars operate in the 1250 - 1350 MHz, 2700 - 2900 MHz and the 5400 - 5900 MHz frequency bands, respectively. No significant frequency related interference problems are anticipated although the possibility of HPE interference does exist and some corrective action could be required. Any required corrective action can be determined in later analysis.

3.3.1.8 From an EMC viewpoint, there do not appear to be any EMC problems which could preclude deployment of a SPAR at North Truro. There are several problems which need further analysis to determine their scope and to determine proper solutions. These include the in-band systems (para 3.3.1.2), the GATR equipment (para 3.3.1.3) and the radars presently located at North Truro (para 3.3.1.7). It is believed that none of these problems will negate North Truro as a prospective site and that reasonable solutions exist in all cases.

3.3.2 Facilities.

3.3.2.1 The present power supply at North Truro AFS is inadequate to handle the SPARS requirement of approximately 3600 KW. The station power plant contains 2 - Chicago-Pneumatic 300 KW diesel generators, 2 - Superior - White 300 KW units, 2 - Superior - White 400 KW units and 1 - 100 KW unit for a total 2100 KW capacity. The Chicago-Pneumatic equipment has bad bearings with one engine under repair. The peak load of 920 KW occurs in the summer season. Most of the non-technical load is supplied with commercial power from a 1000 KVA, 2200V/4160V transformer substation. The commercial supply is reported to be unstable and unreliable with many outages from storms. A new power supply will be required for the SPARS.

3.3.2.2 All buildings supplied with water connect to the central sewer system except for the GATR site, the Commissary Store and the Hobby Shop which have individual septic tanks. The central system connects to a treatment plant which digests, aerates, chemically treats and filters the sewage. The sewage system has additional capacity at least sufficient to accomodate the former station complement. (83 more than present manning). The present sewage disposal system should be adequate for the SPARS personnel requirements. A separate disposal system will be required for discharge of equipment cooling water.

3.3.2.3 The present water supply is obtained from an artesian well built in 1964. It's capacity is 300 gpm, but the average consumption is only 25,000 gpd (17 gpm). There is a concrete, earthmounded, 100,000 gallon water storage tank and a system of hydrants and hose houses throughout the station. The present well, storage tank and fire protection system are adequate to handle the SPARS requirement. New construction is necessary for extension of the water lines and fire protection system to the SPARS location, and for a new back-up artesian well. Additional new water supply will be necessary for any special equipment cooling requirements.

3.3.2.4 The station has no personnel assigned for a fire department, and presently has a single 500 gal storage pumper truck. North Truro AFS has working agreements with adjacent towns for mutual assistance in the event of fire. This arrangement should be satisfactory for SPARS.

3.3.2.5 There is no railroad line nor commercial gas pipeline within 40 miles of North Truro. Both services terminate at Hyannis, MA.

3.3.2.6 Garbage and rubbish are removed by contract and are deposited at the North Truro town dump. This procedure should be satisfactory for SPARS.

3.3.2.7 The station is heated by a central steam heating plant with two 60 HP boilers. Steam is distributed by overhead lines. Present station load is near the capacity of the steam plant. A new heating system will be needed for any SPARS heating requirement. However, the proposed radar will generate heat which may suffice to provide heat for the SPAR system.

3.3.2.8 Medical needs at North Truro AFS are taken care of by three medics at the station in addition to a local contract doctor. The nearest hospital is located in Hyannis, MA. These provisions will be satisfactory for SPARS.

3.3.2.9 There is no extra warehouse space available for SPARS use. The present Unit Supply Warehouse and Civil Engineering Warehouse are fully utilized. New warehouse construction will be required for the SPARS.

3.3.2.10 There are presently 27 housing units at the station and 32 leased units in the surrounding communities. This total number is insufficient for the current manning at North Truro. If the SPARS were installed at the station with military manning, another 35 to 40 housing units should be constructed. The station complement now consists of 132 enlisted men, 8 officers and 32 civilians. Approximately 75 additional personnel are anticipated for the SPARS installation. It is possible that the SPARS radar will be positioned so as to require the relocation of 6 or 7 of the existing family housing units, although alternate measures can be taken to avoid this.

3.3.2.11 The existing dorms for enlisted men do not meet minimum standards and have insufficient capacity to accomodate the SPARS manning. Approximately 15,000 SF of new dorms will be required. In addition approximately 2000 SF of new officers quarters will be needed for SPARS.

3.3.2.12 A new security guard house complete with security fencing will be required at the SPARS installation. Hazard fencing will also be needed at the safe distances for personnel and for wearers of cardiac devices.

3.3.2.13 The present Hobby Shop at North Truro AFS is adjacent to the proposed SPARS site and will have to be relocated to the northern part of the station. The helicopter landing pad and sewage disposal plant are also close to the proposed SPARS site. The landing pad may require relocation but the sewage plant is largely protected by intervening high ground.

3.3.2.14 There may be a need to upgrade the dining areas and kitchens; however, the present facilities have accomodated a larger station complement (83 added personnel) in the past.

3.3.2.16 The proposed SPARS location is approximately 150 feet inland from the top of a cliff which is 150 feet above the ocean beach. Wave action causes significant erosion of the cliff along its entire length. Horizontal erosion of the cliff proceeds at a rate of three feet per year in some locations, but approximates one foot per year at the North Truro AFS. This rate of erosion should not interfere with the SPARS installation within the next 50 years.

3.3.2.17 The soil at North Truro consists of sand and gravel originally deposited as glacial outwash plain. The material is free draining and is not susceptible to significant frost action. The water table is approximately 150 feet below grade. The soil should present favorable foundation conditions.

3.3.3 Radiation Hazard

3.3.3.1 Radiation hazards at and near the radar site were considered for the following categories:

a. Biological

b. Cardiac devices

c. Ordnance

d. Fuel

References T.O. 31Z-10-4 and AFM 127-100 were used for guidance. There is no formal guidance relating to electromagnetic interference levels for cardiac devices, however based upon the latest considerations of the AF Surgeon General, a value of 200 volts/meter peak was used in determining safe distances for the cardiac pacemaker.

3.3.3.2 The following assumptions were made in arriving at the safe distances for each of the radiation hazards:

a. Minimum elevation angle of main beam 3^{o}.

b. Beam width 3^{o}.

c. Side lobe suppression below main beam in vertical plane is -25db.

d. Maximum gain of main beam is 35db along boresight.

e. Duty cycle is 5%.

f. Total scan angle is 240^{o}.

3.3.3.3 Biological Effects - These criteria limit the radiation to 10 mw -2cm for all personnel. Minimum safe distance on the ground is 150 feet.

3.3.3.4 Fuel Hazard - The criterion of 5mw -2cm peak limits the minimum safe distance on the ground to 30 feet.

3.3.3.5 Ordnance Hazard - In accordance with AFM 127-100 the maximum safe distance on the ground is 2,370 feet.

3.3.3.6 Cardiac Pacemaker Hazard - The assumed criterion of 200 volts/meter peak results in the minimum safe distance on the ground of 800 feet.

3.3.3.7 There are no existing fuel or ordnance hazards existing at this site.

3.3.4 Communications.

3.3.4.1 The present telephone system is operated and maintained by the New England Telephone Company. It consists of approximately 206 circuits, the majority of which are used for SAGE Operation. Of particular interest to this survey are cables marked P4 and P5 feeding from the New England Telephone equipment room to the GATR Site. Approximately 113 pairs are available for future use. These circuits could provide required communications during the initial construction phase until other facilities are installed. For data transmission, two methods are available; T-carrier and LR microwave. Bandwidth of these circuits is approximately 3000 Hertz with a bit rate of 1300/Sec. A maximum bit rate of 2000 Bits/Sec is available with the limitation being quality of present circuits and type data sets being utilized. Standard KW-7 on line crypto with one teletype loop is utilized for secure communications. New England Telephone Co. presently plans to update the communication capabilities. When completed the communications will be adequate to provide service for SPARS.

4.0 EVALUATION AND RECOMMENDATION

4.1 As discussed in earlier paragraphs, the choice of sites was narrowed to two locations, North Truro AFS and Montauk AFS. Of the two, North Truro AFS was determined to be more suitable for the following reasons:

a. Montauk AFS is located in the path of major air traffic from New York City, whereas there are no airways near North Truro AFS.

b. The Terrain at North Truro AFS is more suitable for a SPARS installation than at Montauk AFS. The land is level and cleared, situated at the top of a cliff 150 feet above the sea with a commanding overlook of the land and sea in the intended sector of radar coverage. At Montauk the terrain is more irregular, is partially wooded and offers no unused high ground.

c. There are 40 acres of property at North Truro AFS which are excess to the present needs of the station, and which are available for SPARS.

d. During recent years the station complement at North Truro AFS has been reduced by 83 personnel. Consequently many of the existing support facilities are adequate to accomodate the additional manning for SPARS.

e. The SPARS installation can be sited so that the radar beam will not interfere with present installations and activities at North Truro AFS, with the exception of the Hobby Shop and helicopter landing pad. At Montauk AFS the radar cannot be sited without more extensive conflict between the radar beam and existing station activities.

f. There are no highways or concentrations of population within a mile of the SPARS location at North Truro AFS. However, at Montauk AFS a highway abuts the station property.

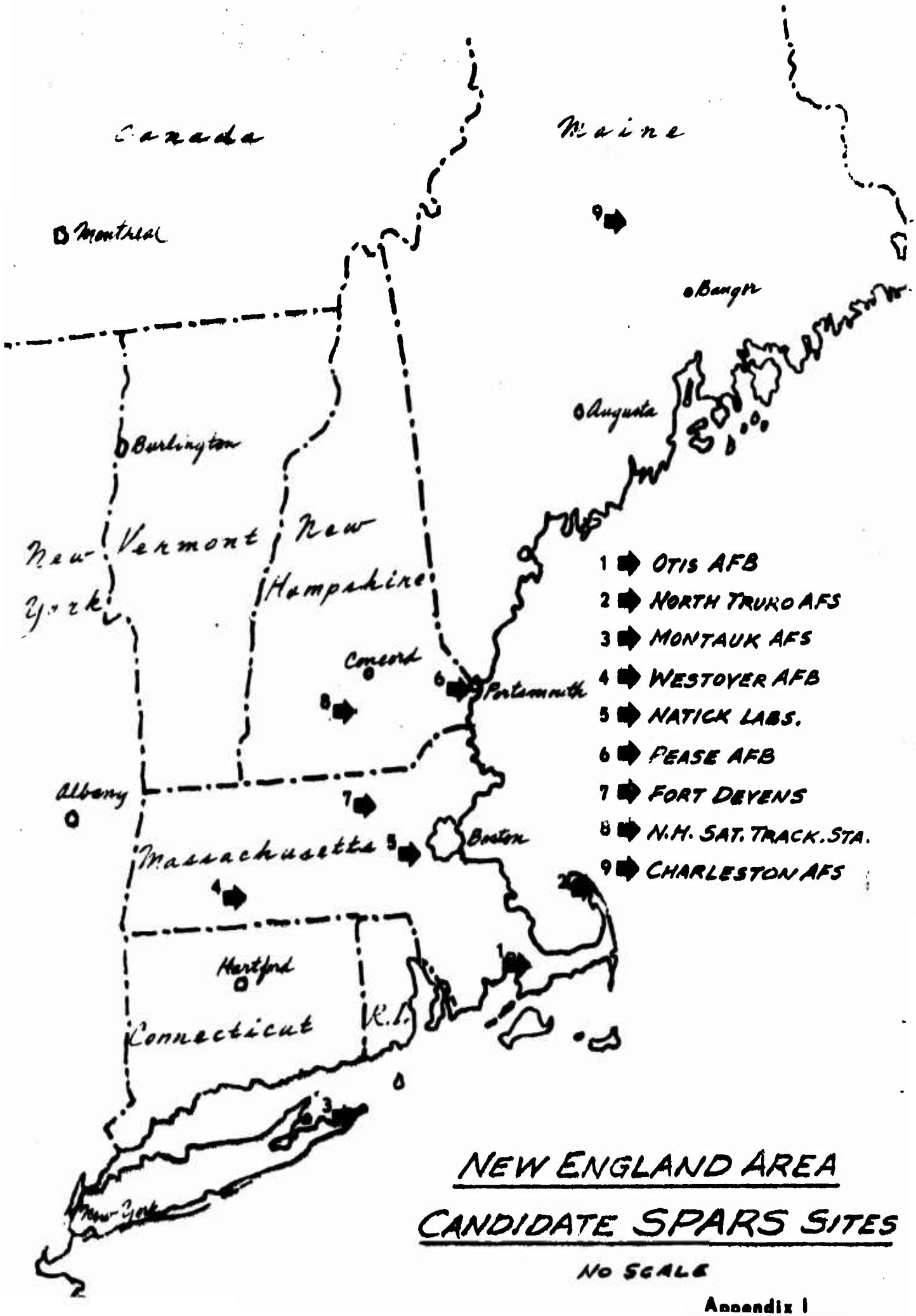
4.2 Appendix II, several possible locations are shown for the SPARS installation at North Truro AFS. Site A was considered first because it provides the least interference with other activities at the station. However, the radar would be positioned only 420 feet from the property line to the south, and the radiation would be hazardous to personnel with cardiac devices who might use that portion of the adjacent National Seashore Park. Site B was then considered since it is located 800 feet north of the property line, and presents no hazard to personnel in the park. But the radar sector of coverage from this location would interfere with some of the family housing units. There are various solutions to this problem including blanking of the radar beam, installation of shielding fences, further relocation of the radar toward Site C, relocation of the family housing units or a combination of these measures.

4.3 In summary, the results of this site survey are favorable for the location of the SPARS installation at North Truro AFS. The problems identified during this survey in the areas of EMC, facilities support, new construction communications, radiation hazard and logistic support are few, and are considered to be less significant than those which would be encountered at Montauk AFS. It is the recommendation of this report that the Northeast SPARS installation be located at North Truro AFS.

5.0 APPENDICES

5.1 Appendix I. Map of New England area showing candidate site locations for Northeast SPARS.

5.2 Appendix II. Station layout for North Truro AFS.

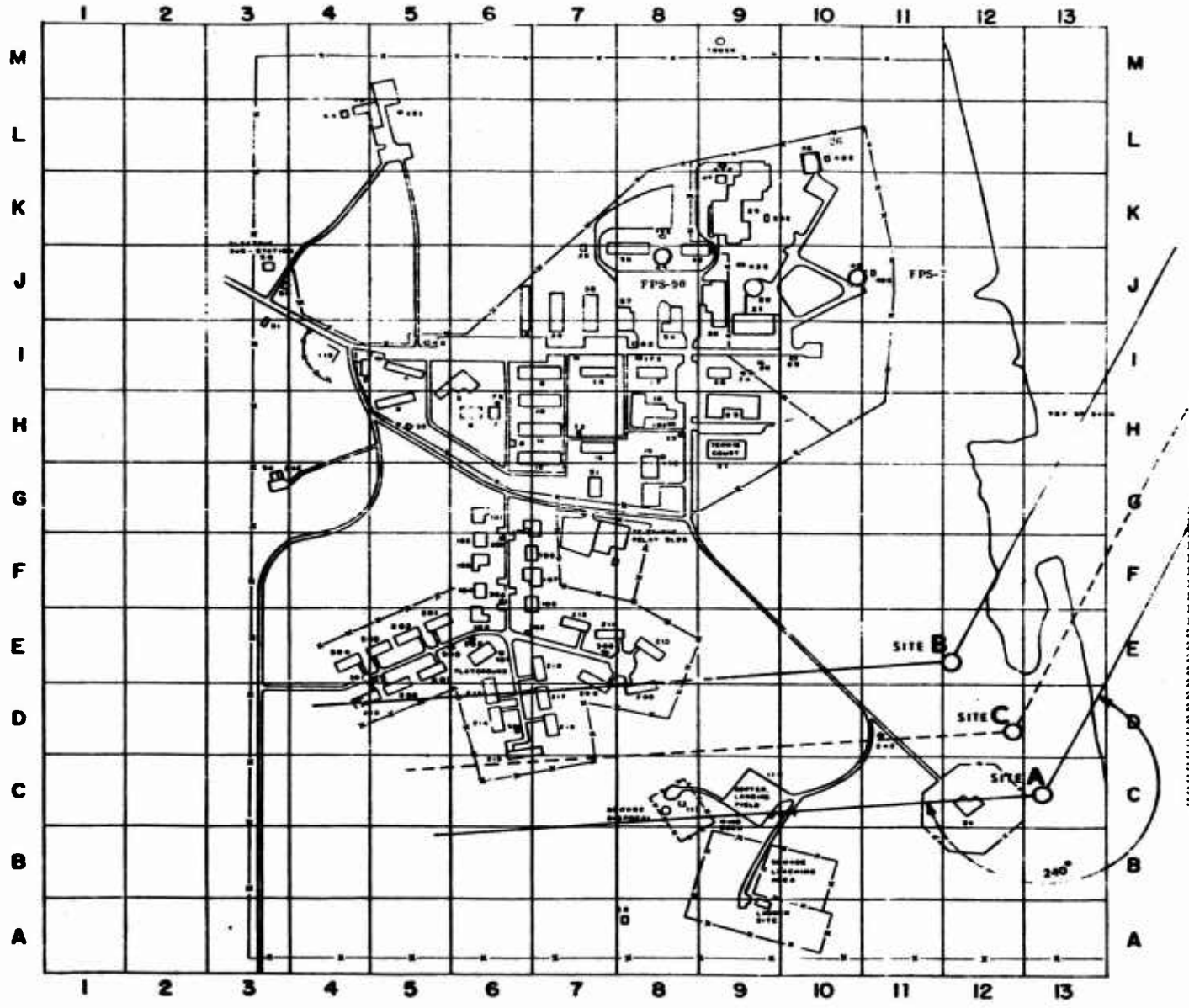


NEW ENGLAND AREA

CANDIDATE SPARS SITES

NO SCALE

Appendix I



BUILDING SCHEDULE

2	Chapel	38	Dormitory
3	Whse. Supply	39	Dormitory
4	Dispensary	40	Radome Tower FPS-7
5	Open Mess, NCO	42	Fire Hose House
6	Water Stor. Tank	44	Warehouse
7	Water Treat. Bldg	47	Store, Commissary
8	Fire Hose House	48	Supply House
9	Hq & Admin	48	Radome Tower FPS-26
10	Dormitory	49	Radome Tower FPS-90
11	Dormitory	50	Elec Sub Sta
12	Dormitory	51	Traffic Control Hse
13	Fire Hose House	54	to 55 Water Pump Sta
14	Exchange Sales Store	60	Exchange Serv. Sta
15	Bowling Ctr	61	Court Rec
16	Recreation Multi-Pur	62	Veh. Fuel Sta
17	Supply and Issue	71	Stor Diesel
18	Dining Hall	74	Flagpole
19	Heating Plant	101	to 109 Family Hsg
20	Fire Hose House	115	Softball Field
21	Recreation, Court	116	Helicopter Pad
22	Recreation, Multi-Pur	117	Sewage Treat. Plt.
23	Officers Qtrs	201	to 215 Family Hsg
24	Hobby Shop	300	to 302 Fire Hose House
25	Fire Hose House	303	Bus Sta
26	Stor Oil-Grease	305	to 309 Fire Hose House
29	Operations Bldg		
31	Elec Power Bldg		
32	Warehouse & Office		**Off Base Facilities**
33	Classroom & Thtr & Sentry Hse	2	GATR Bldg (1 Mile South)
34	Storage & Fire Sta		
35	Stor Pt & Dope	31	Leased Family Housing Units within 26 Mi. radius of Station.
36	Maint Shop		
37	Auto Maint Shop		

200 0 200 400 600 FEET

GRID MAP
NORTH TRURO A.F.S.

Appendix II

PHASED ARRAY WARNING SYSTEM

PAVE PAWS

SITE SURVEY REPORT

FOR

EAST COAST LOCATION

MARCH 1975

Table of Contents

ABSTRACT

A Site Survey consisting of desk studies and a field visit has been performed at Otis AFB, Massachusetts, in the past several months to determine a suitable site for the East Coast PAVE PAWS. Reference is made to the previous site surveys for locations in the New England area.

The result of this survey indicates that Pine Hill on Otis AFB is the most suitable location for the East Coast PAVE PAWS.

1.0 INTRODUCTION.

1.1 Purpose. This report covers the site surveys conducted by ESD to select the most suitable location for the PAVE PAWS.

1.2 Authority. The authority for PAVE PAWS is the AFSC Form 56, 2059-1-74-12, dated 20 September 1973, Coastal Defense Radar System.

2.0 BACKGROUND.

2.1 For a description of the PAVE PAWS refer to ESD System Performance Specification, SS-OCLU-75-1, 1 March 1975.

2.2 A Site Survey Report for Northeast Site Location, SLBM Phased Array Warning System, November 1973 describes in detail the locations considered.

2.3 That Site Survey considered nine possible locations for locating the PAVE PAWS. Two of these were eliminated because of DOD action to curtail USAF activity at those bases. The result of the survey selected N. Truro AFS, Massachusetts as the site for the PAVE PAWS.

2.4 Further studies after the survey had been completed revealed that the proximity of the N. Truro site to the Cape Cod National Seashore created a potential hazard to the environment of the National Park. (Since the survey in November, 1973, the criteria for radiation hazards have been further defined and strengthened.) The solution of this problem could have an impact on the Program Schedule and a restriction on the performance of the PAVE PAWS.

2.5 Studies also indicated that potential savings of at least $2.5 million could be realized in initial construction costs by locating the PAVE PAWS at Otis AFB, MA (one of the sites eliminated previously - see 2.3) vice N. Truro AFS.

2.6 CSAF/PRPO 131842Z DEC 74 message granted approval for the conduct of a site survey at Otis AFB.

2.7 The results and findings of the site survey at Otis AFB are presented below.

3.0 FIELD SURVEY

3.1 Participants

3.1.1 During the period from 7-9 January 1975, the following personnel participated in the site survey of Otis AFB and the Pine Hill site.

Site Survey Team:

I. Etkind (Team Chief)	ESD/OCLE
J.F. Graham, Capt	ESD/OCLE
W. Rosaluk, Capt	ADC/XPQD
L. Blaisdell	ESD/DEE
R. Boldt	ADC/LGXP
J. Stark	ADC/DEPR
O. Ellickson	ADC/DEPE
P. Koegler	RADC/OCDE
C. Pankiewicz	RADC/OCTS
P. St. Thomas	AFCS/EPECC
H. Sieman	ECAC

Personnel Contacted:

Col LaForest	Cmdr ANG
Col Gilmore	ANG
Capt Zumstein	US Coast Guard
Cmdr Amaral	US Coast Guard
Lt Col Sheasley (US Army)	Cmdr Camp Edwards
Lt Col Kerr	ANG 102 BDCA
Lt West	ANG
MSgt Halloran	ANG 102 BDCA
TSgt Porter (US Army)	Camp Edwards
C. Marr	4789 ABG (OLAG)
J. Thomas	ANG 102 BDCA
E. Merritt	ANG 102 CE

3.1.2 Subsequent to the survey of Pine Hill, an alternate site on Otis AFB was suggested by the Army National Guard. As a result, a team from ESD/OCL visited the suggested site of Deer Horn Hill. The OCL team included:

Mr. R. Moore	ESD/OCL
Major G.F. King	ESD/OCLE
Mr. I. Etkind	ESD/OCLE

3.2 Performance of Survey

3.2.1 The survey team inspected the Pine Hill site and reviewed the facilities and services available at Otis AFB. The OCL team inspected the Deer Horn Hill site. This report is a compilation of the inspections and of the data gathered from the briefings and conversations with the Otis AFB and Camp Edwards personnel. No contact was made with the civilian community since the site location has not yet been declassified.

3.3 Findings

3.3.1 Electromagnetic Compatibility (EMC)

3.3.1.1 Considerations. Described below are all sources of possible Electromagnetic Interference (EMI) between PAVE PAWS and its environment.

A. Commercial Radio and Television Stations. The following stations broadcast within the local area.

	FREQUENCY	STATION CALL	LOCATION
TV			
	83.260 MH_z	WTEV (Channel 6)	New Bedford
RADIO			
	1240 KH_z	WOCB	Hyannis
	1340 KHz	WNBH	New Bedford
	1390 KHz	WPLM	Plymouth
	1420 KHz	WBSM	New Bedford
	96.0 MHz	WVLC	Orleans
	97.3 MHz	WGYC	New Bedford
	98.1 MHz	WMYS	New Bedford
	98.5 MHz	WOCB	West Yarmouth
	99.0 MHz	WVOI	Martha's Vineyard
	99.1 MH_z	WPLM	Plymouth
	100.0 MH_z	WQRC	Hyannis
	102.0 MH_z	WCIB	Falmouth
	106.0 MH_z	WCOD	Hyannis

B. Other Radio Links. The following communication links exist in the local area.

AGENCY	TYPE	FREQUENCY	USE
USCG	Radio	VHF/UHF	Air to Ground Communications from Manomet to Western North Atlantic and the Great Lakes area.
USCG	Radio	HF (2-12 MH_z) (also 400KH_z rescue 500KH_z)	
USCG	Microwave	Trans: 1812 MH_z Recv: 1776 MH_z	8 channel link to Manomet, connecting to (US Coast Guard station). This link controls the HF transmitters at Manomet.
USCG	Microwave	Trans: 1739 MH_z Recv: 1711 MH_z	8 channel link from Manomet to Marshfield.
ANG	Radio	VHF/UHF	Air to Ground
ANG	Radio	HF	Emergency assistance to Cape Cod fire departments.
ADC	Microwave	3700-4100 MH_z	SAGE LINE on station originating in N. Truro, and linked via Sandwich.
Command Post	Radio	UHF	Emergency Net
Base Units	Radio	FM	Security, Crash and Fire, Taxi, etc.

C. Landing and Navigational Aids.

AGENCY	TYPE	FREQUENCY	USE
FAA	AN/ASR-5	S-Band	Airport Surveillance
FAA	ILS		
FAA	TACAN	1192 MH_z(Channel 105)	
ANG	AN/TPN-16	X-Band	Ground Control Approach.
Hyannis	TACAN	1181 MH_z(Channel 94)	

D. Radar Systems

AGENCY	TYPE	FREQUENCY	USE
USCG	AN/APS-31	X-Band	Shop Maintenance Facility
USCG	AN/APN-95	X-Band	Shop Maintenance Facility
ARMY	AN/MPQ-4	X-Band	Mortar Location

E. Airborne Equipment

AGENCY	TYPE	FREQUENCY	USE
USCG	AN/APS-31	X-Band	
USCG	AN/APN-95	X-Band	
NAG	(F-106)	X-Band	Fire Control System
ALL	ALL	HF/VHF/UHF	Air to Ground

F. Residential/Commercial Equipment. Within the base, and especially in the housing areas, there exist numerous television sets, radios, and other home electronic equipment.

3.3.1.2 Conclusions.

A. Considering all of the above equipments, there are no known possibilities for Electromagnetic Interference existing in the PAVE PAWS environment, with the exception of the phenomenon of "high power effect," described in the following paragraphs.

B. "High Power Effect" is the possible interference that can result to electronic equipment in close proximity to a high power density radio frequency signal. There are three representative baseline radars being considered for the PAVE PAWS, and the minimum safe distances from the face of the radar for each are:

High Power Effect	L-Band	UHF(tube)	UHF(solid state)
Criterion: 40dbm/m^2, peak power			
Main Beam	20.65 mi.	10.52 mi.	5.54 mi.
Side Lobe	.87 mi.	1.05 mi.	.55 mi.

Unshielded equipment within these minimums would experience interference, much the same as a car radio experiences when in proximity of a radio transmitter antenna. But the effect of the high power on equipment is directly correlated to the design and quality of the equipment, and the amount and placement of shielding provided.

C. The PAVE PAWS main beam will be operating at some fixed elevation above the horizon, nominally 3°, with the site elevated above the surrounding terrain. (The PAVE PAWS can operate at a 0° angle, but local conditions may dictate operational restrictions for this capacity). For this discussion, it is assumed that sidelobe effects will occur at ground level within the 240° azimuth scan angle. Table 1 gives the measured distances from both surveyed sites to key points in the PAVE PAWS environment. (Also see Appendices II and III.)

D. Because of the elevation of the site itself, plus the elevation of the main beam, the high power effects from the main beam will have no effect on ground based equipment. The only equipment which can be affected by the main beam is that equipment in aircraft which may penetrate the field of the radar. The minimum safe distances, given above, are for unshielded equipment. Military and commercial aircraft will provide a conservative minimum of 15db shielding to any and all equipment within the aircraft (Reference AFSC Design Handbook 1-4, Electromagnetic Compatibility (EMC), Design Note 5F8.) This 15db shielding reduces the minimum critical distances in the main beam to 0.66, 0.33 and 0.18 miles, for the respective radars. Due to the random and instantaneous illumination of aircraft by the main beam, and the passage of aircraft through the area illuminated by the main beam, the high power effect would not affect the operation and safety of an aircraft which might penetrate the main beam within the above distances.

Distance Calculations

	Pine Hill	Deer Horn Hill
a. Elevation	300 ft. msl	260 ft. msl
b. Beam crosses highway No. 28 at angle of 235° nearest distance	1.25 mile	.88 mile
c. Nearest distance to impact area	.51 miles	5.3 miles
d. Nearest point to extended runway 14/32 centerline	1.43 mile	2 miles
e. Nearest point to extended runway 5/23 centerline	3.9 miles	2.8 miles
f. Nearest point to runway 14/32 touchdown	3.14 miles	2.7 miles
g. Nearest point to runway 5/23 touchdown	4 miles	3 miles
h. Distance of site to highway No. 28 (in back lobe)	.91 miles	.625 miles
i. Distance to Ammunition Dump	.88 miles	2.7 miles
j. Distance to maintenance area for F-106 aircraft	4.8 miles	3.5 miles
k. Distance to base housing area	2.8 miles	.3 miles

NOTE: All miles are statute miles.

Table 1

E. For the high power effect from the RF energy in the sidelobes, the two sites must be examined individually. At the Deer Horn Hill site, all three baseline radars could cause high power effects in varying degrees. At this location, the high density area of the base begins within 1600 ft. to the East of the radar face. This area includes housing, barracks, and support facilities (e.g. Base Exchange, service station, etc.) For fixed equipment (e.g. televisions, radios, etc.) located within this area, the solution for high power effects is to modify each affected piece of equipment on an individual basis. Car radios, mobile communications, etc., can also be affected within this area, and high power effects will be solved in each case. The solution is relatively inexpensive, and the PAVE PAWS contractor would be required to make the necessary modifications to affected equipment. In addition to the above area, the distance to the State Highway 28 is .625 miles in the backlobe, where the L-Band radar could cause an effect on vehicular equipment. The effect, though, is minimized because it is in the backlobe where lower levels exist due to the unique design of a phased array radar.

F. At the Pine Hill site, the only area illuminated by the sidelobes of the L-Band and UHF (tube) radars is the artillery impact area, which is .51 miles due east of the radar face. But there should be minimum, if any, electronic equipment in this area. The ammunition dump is on the fringe of the L-Band side lobes, but there are plans to relocate the ammunition dump.

3.3.2 Radiation Hazards

3.3.2.1 Considerations. Radiation Hazards can present a threat to personnel, equipment, components, fuel and ordnance, both ground-based and airborne. These can be categorized as biological effects, fuel hazards, ordnance hazards, cardiac pacemaker hazards, and receiver burnout hazards.

A. Distances of the two proposed sites to various places where aircraft, automobiles, personnel, or fuels and ordnance are likely to exist are listed in Table 1. Actual distances may be slightly greater, since site elevation was ignored in computing distances.

B. Parameters for representative baseline radars are shown in Table 2.

Radar Parameters

Band	L	UHF	UHF
Type	Tube	Tube	Solid State
Peak Radiated Power (Megawatts)	6.8	3.6	1.0
Pulse width (milliseconds)	2	2	10
PRF (Pulses per second)	27	27	27
Antenna Gain (db)	43.1	40	40
Average Power (Kilowatts)	340	180	300
Duty Cycle	0.05	0.055	0.27
Sidelobe (db)	27.5	21.1	20.0

Table 2

C. Using the radar parameters, Table 3 was constructed to show the minimum safe distances. Below these minimums, various radiation hazards may exist from the main beam and sidelobes. The criteria used to baseline the radar designs are 1) MIL-STD-469, Radar Engineering, Design Requirements - Electromagnetic Compatibility, and 2) the O.T.P. Manual, Office of Telecommunications Policy Manual of Regulations and Procedures for Radio Frequency Management. The criteria for establishing the minimum distances are 1) AFM 127-100 Explosives Safety Manual (2 December 1971), 2) ASD Message 221340Z JAN 1975 amending safety criteria of AFM 127-100, 3) T.O. 31Z-10-4 Electromagnetic Radiation Hazards (1 June 1971), and 4) Recommendations for Radiation Criteria for Cardiac Pacemaker from USAF School of Aerospace Medicine.

3.3.2.2 Conclusions

A. The only known radiation hazard which the sidelobes of the radar may present in the environment at either site is the danger to personnel wearing cardiac pacemakers. The System Specification requires that the radiated peak energy from the radar sidelobes shall not exceed 200 v/m at a distance of 1500 ft. at any beam position. The USAF Surgeon General is presently investigating this area to further define the pacemaker criteria, and if further, more stringent, energy levels are required, a perimeter fence will be constructed to absorb the RF energy levels. In any event, a perimeter fence warning of the radiation hazard will be erected. All other areas investigated for existence of radiation hazards from the sidelobes are well beyond the minimum safe distances prescribed by Table 3.

B. As described in 3.3.1.2, the main beam of the PAVE PAWS will be operated at some level above the horizon, and the site itself is elevated. This combination obviates any radiation hazards from the main beam to personnel, ordnance, fuel, structures, and towers located on the base. The areas where the main beam may present radiation hazards are discussed in the following paragraphs.

C. The first radiation hazard that may exist is an ordnance hazard. The calculated distance from Pine Hill to the extended centerline of the Runway 14/32 is 1.43 miles. The minimum safe distance to "airborne weapon systems with external explosive loads, not in attack mode," for the L-Band system baselined as in Table 2, is 1.52 miles. Aircraft so configured, approaching Runway 14, can penetrate the main beam of this baselined L-Band radar. Therefore, any L-Band radar proposed must and will be critically assessed. The distances for the baselined UHF radars at Pine Hill and for the baselined L-Band and UHF radars at Deer Horn Hill will not present an ordnance hazard to aircraft within the extended runway centerlines. In any event, the local IFR/VFR traffic patterns may have to be modified or restricted, depending on the radar selected, in the area of the PAVE PAWS site.

Minimum Safe Distances

	L-Band	UHF(Tube)	UHF (Solid State)
Biological Effect			
Criterion: $10mw/cm^2$, average power			
Main Beam	1.52 mi.	4,081 ft.	5,070 ft.
Sidelobe	323 ft.	346 ft.	507 ft.
Fuel Hazard			
Criterion: $5w/cm^2$, peak power			
Main Beam	1,542 ft.	785 ft.	414 ft.
Sidelobe	64 ft.	69 ft.	41 ft.
Ordnance Hazards			

1. When Electroexplosive Devices are in an "all up" configuration, the safe distances shown for ordnance hazards are calculated using criteria for the following applications:

Criterion: $100w/m^2$, average power

a) For EED's stored or transported in metallic cans or containers;
b) For airborne weapon systems with external explosives loads, not in attack mode; and
c) For shipments of transportation packaged or configured EED's or explosives items containing EED's being moved inside aircraft.

Main Beam	1.52 mi.	4,081 ft.	5070 ft.
Sidelobe	323 ft.	346 ft.	507 ft.

2. For taxiing aircraft with external explosives loads where such ordnance subsystems are not in the attack mode.

Criterion: $6.63w/m^2$, peak power

Main Beam	25.4 mi.	12.92 mi.	6.8 mi.
Sidelobe	1.06 mi.	1.12 mi.	.68 mi.

Table 3

3. For the distance between any unshielded EED and radiating source:

Criterion: $D = \frac{450}{f}\sqrt{P_tG}$

Where D = Distance in feet
P_t = Peak radiated power
G = Antenna gain
f = Frequency in megacycles

Main Beam	24.4 mi.	38.1 mi.	20.0 mi.
Sidelobe	1.03 mi.	3.25 mi.	2.0 mi.

Cardiac Pacemaker

Criterion: 200 Volts/meter, peak

Main Beam	6.53 mi.	3.34 mi.	1.75 mi.
Sidelobe	1500 ft.	1500 ft.	925 ft.

Receiver Burnout

Criterion: 325 mw, peak power

Main Beam	16.01 mi.	25.44 mi.	13.4 mi.
Sidelobe	.675 mi.	1.42 mi.	.754 mi.

NOTE: All miles are statute miles.

Table 3 (Continued)

D. The second radiation hazard associated with the main beam is one which concerns personnel with cardiac pacemakers. Aircraft transporting passengers can intercept the main beam of any of the radars at both sites. But again, the distances in Table 3 are for unshielded items. As in 3.3.1.2, using 15 db as the shielding provided by the aircraft, the minimum safe distances from the three radars become 1.16, 0.59, and 0.31 miles. Thus, by prohibiting air traffic an appropriate distance from whichever site is selected, a distance dependent on the type of radar, there will be no radiation hazard from the main beam to personnel wearing cardiac pacemakers.

E. A phenonemon known as "receiver burnout" can occur to certain electronic equipment, characteristically, any receiver which couples a received RF signal directly to a crystal unit, such as in a TACAN unit. The criterion used to establish the minimum safe distances is the power which, when directly applied, will burn out a 1N23 diode (a component used in some TACAN sets). An electronic receiver within the minimum safe distance of any of the three baselined radars could experience an excessive RF signal if the frequency of the receiver is in the frequency range of the radar. (The difference between the frequency of the burnout source and the frequency of the receiver can be fairly wide. The controlling factor is the RF bandwidth of the receiver. In the TACAN frequency band, it is not unusual to find equipment with an RF bandwidth in the tens of megacycles). For the equipment which might exist in, or transient to, the area surveyed, there is no known incompatibility with any of the three baselined radars under consideration for the PAVE PAWS.

3.3.3 Communications.

3.3.3.1 Considerations.

The following communications resources are available at the Communications Center.

A. Telephones. A two thousand line, four position telephone system provides direct dial into commercial circuits and into seven autovon lines. Only five hundred lines are being used at present.

B. Autodin. Autodin traffic passes through a twelve card per minute, 150 baud teletype terminal to Hancock Field, NY. In June, 1975, the terminal will be upgraded with the installation of an MDS 2407 Autodin system. There is only limited use of the present system.

C. Other resources. An administrative circuit exists to Peterson Field, Colorado. Three 75 baud circuits to Hanscom AFB provide for the requirements of supply and military and civilian personnel.

3.3.3.2 Conclusions.

A. Necessary communications lines would have to be extended from the Communications Center to the new site. The distance to Deer Horn Hill is four miles; to Pine Hill, the distance is seven miles.

B. The existing telephone and Autodin systems can provide the required support for the PAVE PAWS.

3.3.4 Facilities. There are four major groups involved in the operations at the base: the U.S. Coast Guard (USCG), the Massachusetts Air National Guard (ANG), the Massachusetts Army National Guard (ARMY), and the Aerospace Defense Command (ADC) Caretaker. At the present time, there is no officially designated host organization. However, the lease recently signed with the state for continued federal use of the installation requires that a host be established.

3.3.4.1 Considerations.

A. The base. The base consists of 22,000 acres. 1,700 acres (the airfield proper) are owned by the Air Force; the rest are leased from the state. The plentiful water supply is provided by two 90-foot deep wells. The water table is approximately sixty feet below the surface. The soil consists of silty, sandy gravel, heavily interspersed with larger boulders deposited by the receding glacier.

B. Base Facilities. The coal-burning base heating plant provides central heat to most of the base, using a high temperature hot water system. The coal for the heating plant is delivered via an on-base spur of the Pennsylvania Railroad. The spur also serves a large warehouse complex. The complex consists of 18 units, each with 9200 sq. ft. of space. Only two of these units are presently being used; the others are "pickled," i.e. closed up,with no heat. There is adequate storage for AVGAS, but none for diesel fuel oil.

C. The Airfield. The airfield has two runways, 5/23 and 14/32. The airfield is presently used by ARMY helicopters and light aircraft, USCG rescue aircraft and helicopters, and ANG F-106 fighter aircraft, which can be armed for alert and training missions. In addition, military passenger and cargo aircraft routinely use the airfield. The FAA operates the control tower 24 hours a day.

D. Base Services. The ADC Caretaker presently provides law enforcement and protection for the base. The ANG provides fire protection. The ANG also operates the Base Motor Pool for all tenants. There is presently no base transportation (shuttle) service available. Base Supply support is provided by Hanscom Air Force Base. An area PMEL, on base and operated by the ANG, presently supports 3000 items, and has expansion capability.

E. Medical and Dental. The dispensary operates 24 hours/day, 7 days/week with a staff of one doctor, one dentist and 15 corpsmen provided by the USCG. There are also 3 civilian physicians made available by the ANG. The ANG provides ambulances with operators. For services beyond the capability of the Dispensary, CHAMPUS is used. The hospital in Falmouth is 25 minutes away. Dental services at Hanscom AFB are also used.

F. Mess Facilities. The Coast Guard facility is now at its maximum capacity of feeding 150 people. The ANG has a contract lunch facility which operates weekdays from 1100 to 1400 hours. There is no Officer or NCO Open Mess.

G. Family Housing and Schools. There are 1193 two and three bedroom housing units on the base. At the present time the USCG maintains 403 active units, 101 of which are allocated for Army, Air Force, and Navy use. The electrical distribution and water supply systems in the housing area, which have received little attention in the past several years, require extensive maintenance and replacement. The Bourne School District operates two elementary schools and a junior high school on the base for children of military families and civilian students who are bussed from the surrounding communities. High school students are transported to off-base schools.

H. Barracks. Eleven brick barracks buildings, with 72 rooms each, are run down and in need of repair. Two of these are presently being used by the Army. There is no BOQ or VOQ facility on the base.

I. Support and Recreational Services. The Coast Guard operates the Commissary under provisions of Department of Transportation regulations. The Commissary is self supporting and utilized by all services on the base. The Coast Guard also operates the Base Exchange. Other support services offered on base are a chapel, credit union, bank, laundry and dry cleaners, and service station. A swimming and boating facility, the future of which is uncertain, and a golf course are on base. The base swimming pool is leased to a swim club, but available for use (for a fee) to personnel on station. The bowling alley is closed, but heated and maintained. The three-year-old, air-conditioned theater is also closed.

3.3.4.2 Conclusions.

With Memoranda of Agreement with the applicable organization (or a Host-Tenant agreement with the appointed organization) and augmentation of the service staff to handle the increased functions and personnel, the base is capable of supporting the PAVE PAWS.

3.3.5 Sites.

3.3.5.1 Pine Hill. The elevation (300 ft. MSL) of the land is the highest on the base and the horizon is unobstructed. A chain link security fence encloses a 400' X 400' area which was previously used by the Navy as a communications site. There is a small capacity well and limited commercial electric service to the site, suitable for construction needs. There is an existing structure and an antenna pedestal on the site which would have to be removed. A paved, two-land road connects the site to the main portion of the base. The area due east of the site is presently used by the ARMY as an impact area for artillery training.

3.3.5.2 Deer Horn Hill. Deer Horn is located in close proximity to the main base, but is an uncleared and undeveloped hill, covered with scrub pine. The elevation of 260 ft MSL would have to be lowered three to five feet by grading, to provide sufficient area for the PAVE PAWS structure. The only access to the site is presently an unimproved trail.

3.3.6 Environment.

3.3.6.1 Considerations

A. Temperatures.

		Summer (May - Sept)	Winter (Nov - Mar)
Absolute Maximum		97°F	74°F
Absolute Minimum		31°	-9°
Mean Maximum		73°	43°
Mean Minimum		57°	28°
Mean No of days/year Temp	≥	90°F	1.6
	≤	32°F	101
	≤	0°F	1

B. Humidity

Summer Mean	78%
Winter Mean	75%
Annual Mean	77%

C. Precipitation

Mean Annual	48.9 in.
Maximum Month - August	5.35 in.
All months fairly evenly distributed except June (1.96 in.)	
Mean annual snowfall	36.2 in.
Maximum Snowfall Month -March	10.7 in.
Maximum 24 hour precipitation	7.1 in.
Maximum 24 hour snowfall	21 in.

Mean No of days/year	with precipitation	79.8
	with snow 1.5 in.	7.4
	with thunderstorms	16.4

D. Winds

Prevailing Direction -	Summer	SW
	Winter	NW

Mean Wind Speed	9 knots
Extreme Wind Speed (Gusts)	73 knots

E. The location falls within Seismic Zone 2.

3.3.6.2 Conclusions. Information on low altitude temperature inversions is not available at the time of this report. A detailed analysis has been requested from the Environmental Technical Applications Center (ETAC) of the Air Weather Service. This analysis will provide a detailed evaluation of the inversion and its effects on propagation. It does appear, however, from consideration of the general weather patterns that inversions significantly affecting propagation are rare and should pose no significant problems.

3.3.7 Environmental Impact. AF/PRO direction in December,1974, restricted the site survey to a low key effort to avoid adverse public reaction. Although it is not possible to determine the complete effort which the PAWS will have on the surrounding environment on the basis of a limited site survey, the following observations were made.

3.3.7.1 Socio-economic. The general feeling among local communities is favorable toward continued military use of the Otis AFB/Camp Edwards reservation. The increase in military personnel required to operate and/or maintain the PAWS would serve to lessen the adverse impact of the recent (1973) curtailment of Air Force activities at Otis AFB. There would be small chance of overburdening the public service facilities and utilities in the adjacent communities, since those facilities were capable of serving the larger military population existing at Otis prior to the 1973 curtailment. In fact, most of the housing, feeding and schooling for PAWS personnel will be contained within the confines of the Air Force Base, while some shopping and entertainment will extend to the surrounding towns. Thus the socio-economic impact is expected to be minor but favorable to the adjacent communities.

3.3.7.2 Air and Water. The pollution of air and water resulting from the generation of power and the cooling of equipment will occur within the 22,000 acreas of the military reservation, and (with proper design) should have little noticeable effect on the off-base environment. Water supply at Otis is plentiful and would not be overtaxed by PAWS.

3.3.7.3 Land Use. The installation of a radar system would have minor impact on the present use of the land. The change would be from one military use to another (from a firing range to a radar site). The impact of this change would be contained within the base property.

3.3.7.4 Parks and Historical Sites. Since the radar will be located well within the military property, there will be no impact on any off-base parks or historical sites.

3.3.7.5 Wildlife. Under the limitation of a "low-key" survey, wildlife information is incomplete. However, personnel contacted at Otis advise that problems have not arisen in the past involving the disruption of wildlife in that area, from the operation of aircraft, communication systems, radars and firing ranges. It is known that the wooded areas on-base contain the usual New England wildlife such as fox, deer, rabbits, skunk, squirrel, raccoon, wood chuck, chipmunk etc. Birds such as seagulls, sparrows, robins, hawks, owls, pheasant, quail, grouse, orioles, cardinals, blue jays, woodpeckers, crows, etc. frequent the area. It is not expected that the PAWS will significantly affect the local wildlife.

3.3.7.6 Radiation. Radiation hazard from the operating radars will be minimized and controlled by locating the site at safe distances from all activities, facilities and transportation routes, and by providing shielding fences, hazard fences, and warning signs at appropriate locations. It will be necessary to coordinate with other military users of the Otis AFB/Camp Edwards reservation to assure that there will be no conflict with PAWS radiation distance criteria in the conduct of their operations.

3.3.7.7 On the basis of preliminary, "low key", site investigations, it appears environmental impact from the installation of PAWS at Otis AFB will be minor, and subject to the successful coordination and adjustment of activities among the several military users of the base. Continued study and evaluation is necessary for complete resolution of the radiation hazard impact. Upon approval to conduct "full disclosure" surveys, a final assessment of environmental impact can be made.

4.0 EVALUATION AND RECOMMENDATION

4.1 Formal Site Surveys conducted at N. Truro AFS and Otis AFB have resulted in the determination that both locations are acceptable, but that Otis AFB is the more desirable site for the following reasons.

A. Twenty-two thousand acres of Government property at Otis AFB permit greater flexibility in siting with minimum disruption to other base activities. The large acreage also allows complete containment of the project with minimum impact to the surrounding communities.

B. Otis AFB is forty five miles closer to reliable commercial power of adequate capacity.

C. The normal dead space in sector coverage adjacent to radar extends over land at Otis, thus providing more effective radar coverage of navigable waters than at N. Truro AFS.

D. More extensive communications (telephone, Autodin, Autovon, etc) are available at Otis AFB.

E. More extensive support facilities are available at Otis AFB. (Fire, Police, PMEL, Storage, Quarters, Schools, etc.)

4.2 At Otis AFB, two locations have been surveyed which are technically acceptable.

A. Deer Horn Hill is the less acceptable site of the two because its proximity to a densely populated area of the base can produce possible radiation hazards to base personnel, facilities, and equipment.

B. Pine Hill is the recommended choice for the PAVE PAWS. This site minimizes the impact on the base itself, and negates most EMI and Radiation hazards on the base, its facilities, and personnel. The only impact of locating here is that the artillery range would have to be closed, since the impact area is due east of the radar.

4.3 In summary, the results of this site survey are favorable for locating the PAVE PAWS at Pine Hill on Otis AFB. The conclusions reached in the areas of EMC, Radiation Hazards, Communications, Environment, and Facilities, indicate the fewest problems than at any other site surveyed. This report recommends siting the PAVE PAWS at Pine Hill on Otis AFB.

5.0 APPENDICES

5.1 Appendix I. Map of Cape Cod and vicinity identifying Otis AFB.

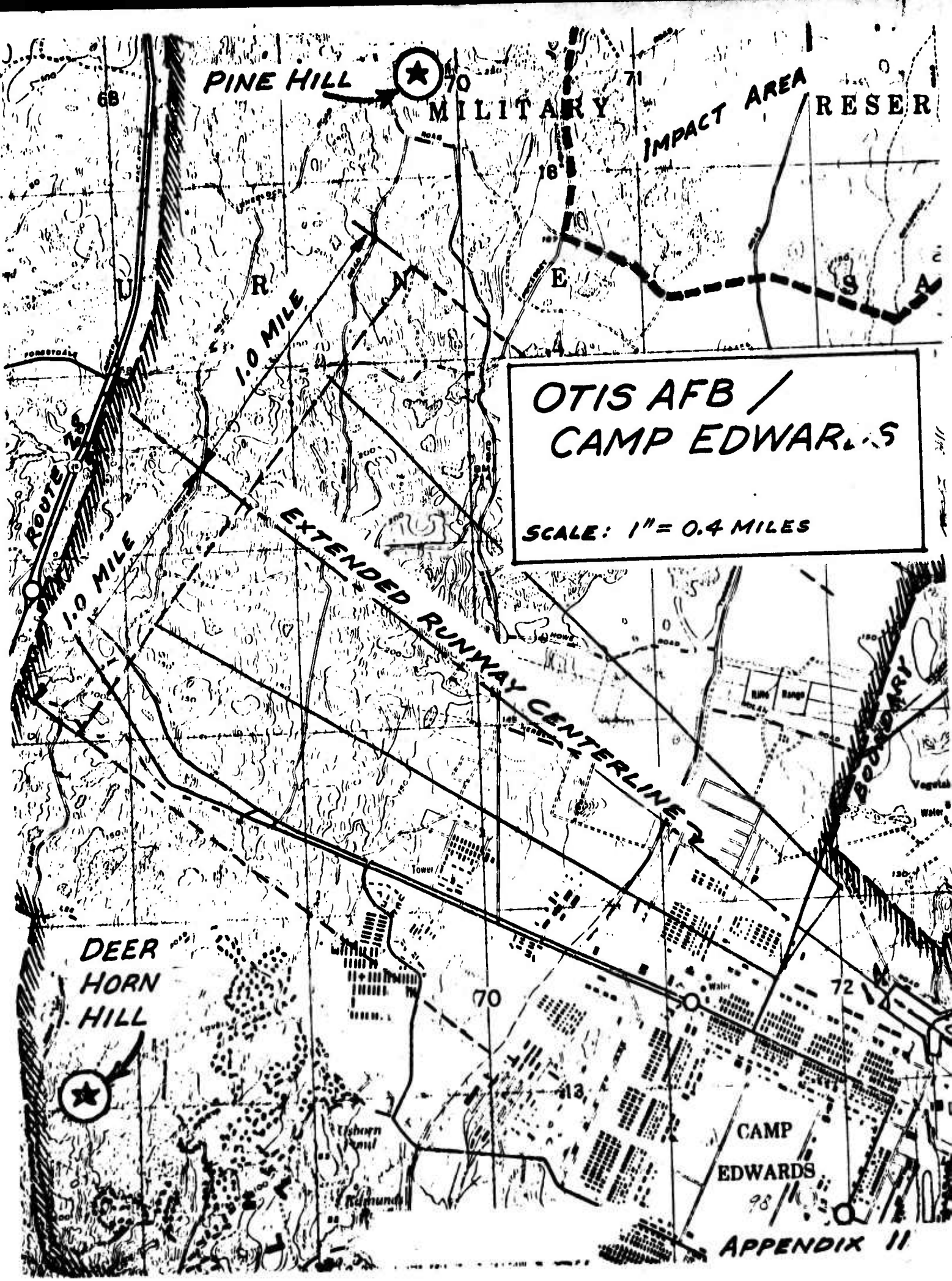
5.2 Appendix II. Map showing two locations surveyed for this report.

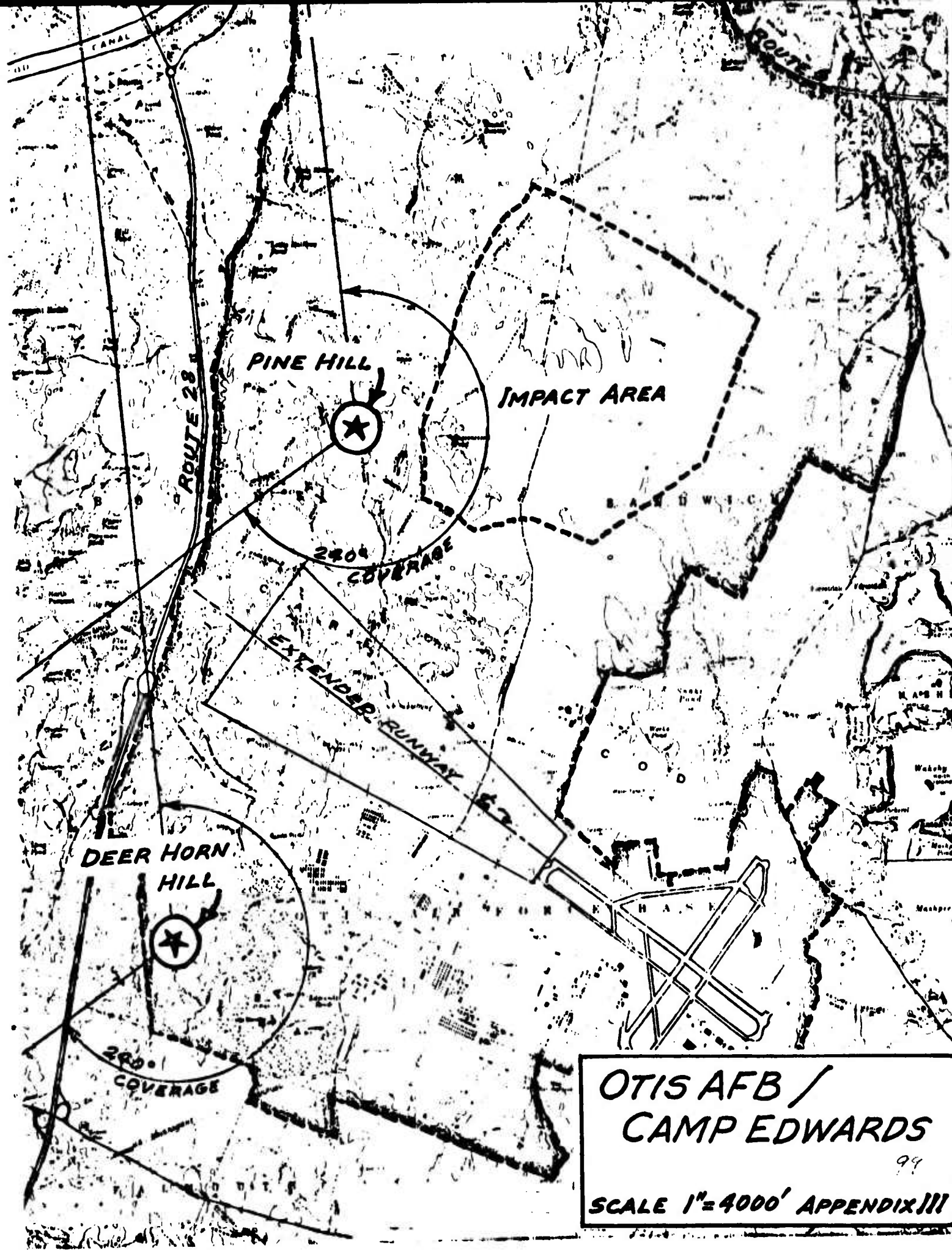
5.3 Appendix III. Map showing two locations surveyed with their 240° azimuth coverage.

LOCATION MAP
OTIS AFB

SCALE: 1" = 7.3 MILES

APPENDIX I


PINE HILL
MILITARY
IMPACT AREA
RESER
1.0 MILE
1.0 MILE
EXTENDED RUNWAY CENTERLINE
ROUTE 28
OTIS AFB / CAMP EDWARDS
SCALE: 1" = 0.4 MILES
DEER HORN HILL
CAMP EDWARDS
BOUNDARY
APPENDIX II


CANAL
ROUTE 6
PINE HILL
IMPACT AREA
ROUTE 28
240°
COVERAGE
EXTENDER RUNWAY
DEER HORN
HILL
240°
COVERAGE
OTIS AFB /
CAMP EDWARDS
99
SCALE 1"=4000' APPENDIX III

SITE SURVEY - OTIS AFB

A.1 On 17 June 1975, a survey was made at Otis AFB for the purpose of determining another site for PAVE PAWS due to the unavailability of Pine Hill and the marginal suitability of Deer Horn Hill. Personnel in the survey party were:

Lt Col Paul T. McEachern

Capt K. Wall

Mr. L. Blaisdell

Mr. I. Etkind

B.1 Since Pine Hill was considered by the Army National Guard to be in a strategic location relative to gun emplacements for the artillary range it was ruled out as a viable site. Deer Horn Hill was acceptable to the National Guard but later abandoned by the Air Force because of PAVE PAWS growth considerations, proximity to the housing area, and potential conflicts with a proposed Veterans Administration National Cemetery.

B.1 It became apparent that the only remaining area in which to look was in the northern sector of the base with due consideration given to distances from Rt. 6, Rt. 28, Cape Code Canal and existing Army National Guard Artillery.

C.1 The area at and near Flatrock Hill was surveyed and several hills were found that with suitable earth work could be made into acceptable sites. One of these sites at an elevation of 280 feet, was at the intersection of Gibbs Road and Maston Road. A 115KV power line

runs directly in front of this site along Gibbs Road. Part of the area is cleared because of the ppwer line. It is felt that these lines would have to be rerouted or run underground for several thousand feet to provide an electromagnetic compatible environment.

C. 2 The area across the street from the previously described location was considered. It is encircled by Gibbs Road, Maston Road and Sagamore Road and is at 270 feet elevation. Some earth work would be required to clear the trees and underbrush and level the earth for sufficient flat area. The same power line would have to be diverted for a part of its run but this case a lesser amount would be affected.

C. 3 The location at Flatrock itself (maximum elevation 270 feet) is equally spaced betweed the two power lines (115KV and 23KV) running on the base. This site requires earthwork to obtain a flat area suitable for a PAVE PAWS building. Further discussion with Army National Guard reveals that Flatrock is the most acceptable to them and would have the least impact on their artillary range. Distances to important landmarks, structures, roads, and boundaries are listed in TableI.

C. 4 The Flatrock site has an unobstructed view along its radiating azimuth. The highest structure (500 ft. above high water) in the vicinity

TABLE I

	Flatrock Hill
Elevation	270'
Nearest distance to Route 6	3500'
To proposed Rt. 25 Extension	2700'
Nearest distance to Impact Area	1.52 mi.
Nearest point to extended runway 14/32	4.73 mi.
Nearest point to runway 14/32 touchdown	5.96 mi.
Nearest point to extended runway 5/23	4.7 mi.
Nearest point to runway 5/23 touchdown	6.06 mi.
Nearest point Rt. 28 inside azimuth coverage	2.94 mi.
Distance to power plant tower in Sandwich	2.08 mi,
Sagamore Bridge (Backlobe)	1.6 mi.
Bourne Bridge (Backlobe)	2.65 mi.
Nearest distance to housing area	6.8 mi.
Nearest distance to 115KV line	2,300 ft.
Nearest distance to 23KV line	2,300 ft.

TABLE I (continued)

Distance to Ammunition Dump	4.16 mi.
Distance to Town of Sagamore	2.5 miles

is the Sandwich power plant tower, a distance of two miles from the site. With a two degree wide radiating beam, the lower extremity of the beam will be two degrees above the horizon for the normal three degree elevation surveillance mode. At this distance the lower extremity of the beam will be about 100 ft. higher than the top of the tower.

D.1 Studies were performed to determine the impact of the power lines to the PAVE PAWS and the effect of RF energy on the power lines. At the Flatrock site the mutual effects are considered negligible. At the present time the power company does not utilize any type of current carrier for load switching on either of the power lines. The company has stated that if a current carrier system is used on the lines, it would be on the 115KV system only, and not sooner than two years from now.

E.1 Minimum safe distances from the Flatrock Hill site for radiation hazards including biological effect, fuel hazards, ordinance hazards, unshielded EEDs and Cardiac Pacemakers are listed in Table II for this proposed radar. It is assumed that PAVE PAWS will be a solid state UHF design.

E.2 No major disruption of normal air traffic patterns in the vicinity of Otis AFB would occur if PAVE PAWS is deployed at Flatrock Hill. It would be necessary to restrict light non-metallic aircraft with passengers having cardiac pacemakers from flying closer than 1.75 miles to the site. Passengers in commercial and military planes will have the advantage of being shielded to a greater extent due to the metal skin of the aircraft. This restricted air space will also apply to aircraft carrying electro-explosive devices.

E.3 Minimum safe distances for personnel and equipments at ground level can be realized because only the sidelobe will be radiating the ground. Shielded EEDs transported in an open truck along Route 6 in the section East of Flatrock Hill are required to be at least 3300 ft. from the PAVE PAWS transmitter. Actually the closest distance is 3500 ft. The area between the site and Route 6 is covered with trees and under brush, which results in a large attentuation in sidelobe radiation. The trees and undergrowth cause the radiation to be dispersed, resulting in much safer minimum distances than calculated.

TABLE II

Minimum Safe Distances for Radiation Hazards

UHF - Solid State

PAVE PAWS

Biological Effect	
Main Beam	3050 ft.
Sidelobe	305 ft.
Fuel Hazard	
Main Lobe	335 ft.
Sidelobe	35 ft.
Ordinance Hazard	
1. EEDs in "all up" Condition	
Main Beam	3050 ft.
Sidelobe	305 ft.
2. Taxiing Aircraft and Aircraft in flight pattern with "wheels down".	
Main Beam	2.2 mi.
Sidelobe	1190 ft.
Unshielded EEDs	
Main Beam	15.2 mi.
Sidelobe	1.5 mi.
Shielded EEDs in Transport	
Main Beam	6.2 mi.
Sidelobe	3300 ft.
Cardiac Pacemaker	
Main Beam	1.37 mi.
Sidelobe	725 ft.

APPENDIX III

TABLE 1

Source of Personal Earnings on Cape Cod in 1969

TABLE 2

East Coast Site Ratings

TABLE 3

Distances to Population Centers

TABLE 1

Source of Personal Earnings on Cape Cod in 1969

Source	Per Cent
Farming	1
Government Payroll (Federal, State and Local)	26
Manufacturing	5
Construction	12
Transportation, Communication, Utilities	8
Wholesale and Retail Trade	23
Services	22
Finance, Insurance & Real Estate	3
	100

NOTE: Table 1 is based on data contained in Cape Cod Economic Base Study, October 1972, Cape Cod Planning and Economic Development Commission.

EAST COAST SITE RATING

TABLE 2

CRITERIA / LOCATION	DOD PROPERTY	150 NM RADIUS	EMC	RADIATION HAZARDS	TOPOGRAPHY	FACILITIES & SERVICES	ENVIRONMENTAL
PEASE AFB, NH	1	1	4	4	4	1	4
FT DEVENS, MA	1	1	3	2	4	2	2
NH SATELLITE STATION	1	1	3	2	4	2	2
NATICK LABORATORIES	1	1	3	3	4	4	3
CHARLESTON AFB, ME	1	4	1	1	4	1	1
ST ALBANS AFS, VT	1	4	3	3	4	2	3
WESTOVER AFB, MA	1	1	2	3	1	1	2
OTIS AFB, MA	1	1	1	1	1	1	1
MONTAUK AFS, NY	1	1	3	4	4	1	3
N. TRURO AFS, MA	1	1	1	1	2	1	2

1. Satisfies all siting requirements.
2. Imposes moderate restriction, disruption or cost increase.
3. Imposes significant restriction, disruption or cost increase.
4. Only marginally acceptable due to serious restriction, disruption or cost increase.

TABLE 3

Distances to Population Centers within the sector of radar coverage from:

	POP.	PINE HILL	and	FLATROCK HILL
Sagamore	1,007	4.5 miles		1.5 miles
Sandwich	5,239	4.7		2.1
East Sandwich	1,677	6.2		4.3
Forestdale	350	3.4		4.3
Mashpee	2,496	5.7		7.4
* Wakeby		4.9		5.8
Santuit	350	7.5		8.8
Marston Mills	953	8.5		9.1
West Barnstable	861	9.5		8.7
Centerville	2,876	11.7		12.1
Hyannis	6,847	14.7		14.4
Hyannisport	500	14.0		14.2
Barnstable	19,842	13.2		12.3
Osterville	1,286	10.4		11.1
Cotuit	900	9.0		10.5
East Falmouth	2,971	8.8		11.8
* Hatchville		5.3		8.3
Falmouth Heights	800	11.2		14.3

* Seasonal Pop. < 1,000

TABLE 3 (Continued)

	POP.	PINE HILL	and	FLATROCK HILL
Falmouth	15,942	10.9		14.1
Woods Hole	950	13.7		16.8
West Falmouth	725	8.0		11.1
North Falmouth	600	5.0		8.2
* Cataumet		4.0		7.2
Pocasset	900	3.0		5.8
Bournedale	957	4.4		---
Sagamore Beach	400	6.2		3.1

* Seasonal Pop. <1,000

APPENDIX IV

PRELIMINARY DRAFT OF

ECOLOGICAL SURVEY REPORT

FOR PAVE PAWS SITE AT OTIS AFB

14 July 1975

DEPARTMENT OF THE AIR FORCE
Air Force Civil Engineering Center (AFSC) OL-AA
Kirtland AFB, New Mexico 87117

Preliminary Draft of
Ecological Survey Report
for PAVE PAWS site at Otis AFB
14 July 1975

INTRODUCTION

Purpose and Scope:

This environmental impact study was conducted at the request of the Electronic Systems Division, Hanscom AFB, MA in support of an Environmental Assessment for the PAVE PAWS ground based radar system.

The study is concerned primarily with the probable impact of operation and construction of this radar system on the natural environment. Our evaluation drwas heavily on the existing ecological condition at Otis AFB and the current and proposed land use patterns for the reservation.

Information in this environmental impact report is based on site surveys, literature reviews and interviews with individuals from the public sector of the Cape Cod area.

SITE DESCRIPTION

Site Locations:

The proposed site for the PAVE PAWS radar installation is on the Otis AFB/Camp Edwards compound (referred to hereafter as simply Otis), Barnstable Co., Massachusetts. In all, four sites have

been considered at Otis (Fig 2, Appendix I). These are Pine Hill, Deer Horn Hill, Flatrock Hill, and the hill marked by Benchmark 280, approximately 2500 feet west-south-west of Flatrock. Pine Hill, although ecologically optimum, would create land use problems. Benchmark 280 would also cause land use conflicts. Deer Horn Hill was found unacceptable because of ecological problems. Flatrock Hill was chosen for prime emphasis as a compromise between land use and ecological considerations.

Geology:

The land is entirely composed of unconsolidated sediments deposited from the Laurentan ice sheet of the Wisconsin glacial stage. The sediments of these formations are predominately sand, gravel, and boulders of granitic origin. The area of Otis contains an abundant amount of kettle holes some of which contain water and are considered to be outcrops of the ground water table.

Soils:

The soils are almost entirely of the Plymouth sandy loams, light and stony phases. They are generally of light to medium texture, containing large amounts of strewn boulders and gravel. The soil is characterized by slow to moderate runoff. Permeability is rapid in the solum and very rapid in the underlying substratum. Associated with the Plymouth sandy loams is the Canton fine sandy loam. Canton soils are a coarse-lowm over sandy mixed

glacial till. These soils are found on hill tops, such as the proposed radar site. They are well drained and runoff is moderate. Permeability is moderately rapid in the solum and rapid in the substratum.

Vegetation:

The potential natural vegetation for this geographical area in which Otis is associated is described as Northeastern Oak-Pine Forest (Quercus-Pinus). Dominants of this association are: Pitch pine (Pinus rigida), scarlet oak (Quercus coccinea) and black oak. Other components are Black Huckleberry (Gaylussacia baccata), Sheep laurel (Kalmia angustifolia), Mountain laurel (K. latifolia), shortleaf pine (Pinus echinata), blackjack oak (Quercus marilandica), chesnut oak (Q. primus) and post oak (Q. stellata).

Field observations indicate that the predominant vegetation for Otis is pitch pine (Pinus rigida), and oaks of the species White Oak (Quercus alba), Northern Red Oak (Q. rubrum), post oak (Q. stellata) and scrub oak (Q. ilicifolia). The understory is made up largely of heath plants, such as large amounts of broken fern, sweet fern (Comptonia peregrina), Common Greenbriar (Smilax rotundifolia), and sprout growths of scrub oak (Q. ilicifolia) and pitch pine (Pinus rigida). Less common were New England Grape (Vifus novae-angliae), Evergreen Bearberry (Arctostaphylos uva-ursi), Sheep laurel (Kalmia angustifolia), and Low-bush blueberry (Vaccinium angustifolivm).

The overstory species can be broken down into the following approximate percentages:

Pitch Pine: 60-65% of the cover

Scrub and White Oak: 30-35% of the cover

All others: 0-5% of the cover

The vegetation in the study area can be characterized as an edaphic subclimax, with the characteristic plant community appearing due to sporadically recurring fires. Some of these fires are started from shelling into the impact zone and spread to surrounding areas. The competing larger trees are killed by fire, allowing and encouraging scrub oak and pitch pine to flourish. At any one area, primary and secondary succession forests can be present. To combat such fires it has been suggested that 4 out of 5 pitch pines be replaced with white pines. This would also encourage growth of the present deer population by providing better forage areas.

Normal successional and climax communities are largely absent from the Otis forests. This is due primarily to the frequent fires (caused by detonations in the Army firing range impact area and stray shots) that have selectively encouraged the pitch pine/scrub oak community that now exists. The community is a mixture of primary growth, including very dense tangles of pitch pine, scrub oak, and smaller bushes and brambles, and more mature areas of large pitch pines (generally not fully grown) and dense understory, including scrub oak. Pitch Pine, in particular, is a well adapted pioneer species. It colonizes waste areas, poor soils, and fire ravaged areas with great success. The Pitch Pine will withstand drought very well, as will most pines. (ref The Genus Pinus) In good conditions,

Pitch Pine is rapidly pushed out by other, larger trees, such as White Pine, Red Pine, or large oaks. As mentioned before, the frequent fires give the pitch pine a competitive advantage over other trees in the area because of its quick growth cycle and hardy temperment. White Pine, Red Oak and Black Oak (the typical dominants) have been excluded from much of the area by the Pitch Pine. After construction of the site, the Pitch Pine would return to the unused areas of cleared land within a few years, if allowed to do so.

Wildlife:

Of the 22,000 acres within Otis AFB, appriximately 17,000 acres can be characterized as suitable habitat for deer and other wildlife. According to a recent interview with Mr. H.A. Weisner, of the Division of Fisheries and Games, the area of the proposed site at Flatrock Hill, is among the better deer hunting areas. The dense growth of pitch pine and scrub oak, though providing escape cover and nesting for a wide variety of birds, seems to be a poor cover and nutritional source for the Cape's some 175-225 resident White Tail deer (Odoclileus virginianius). This poor but suitable deer habitat is offset by the large contigious land mass that they can occupy.

Game birds ovserved on the site survey included Ruffed Grouse (Bonasa umbellus) and Bobwhite Quail (Colinum virginianus). Other avian species seen were: Herring Gull (Larus angentatus), Goldfinch

(Spinus tristis), Osprey (Pandion Haliaetus), Red-tailed Hawk (Buteu jamaicensis), Blue Jay (Cyanocitta cristata), Mockingbird (Mimus polyglottis), Brown thrasher (Toxostoma refum) and Robin (Turdus migratorius). In addition to what was seen, there are well over 100 species of migratory or seasonal birds that use the area. (See Attachment 1.)

Common mammals include the Virginia Whitetail deer (Odoclileus virginiandus), Snowshoe Hare (Lepus americanus), Red Squirrel (Tamiasciurus hudsonicus), Eastern Chipmunk (Tamias striatus), Red Fox (Vulpes fulva), Gray Fox (Urocyon cinereoargenteus), Racoon (Procyon lotor), Shortail Weasel (Mustela erminea), and Woodchuck (Marmota monax).

Climate and Coastal Habitat:

Cape Cod experiences a high percentage of fair weather with an average annual rainfall of 42 inches. Temperature extremes range from -9 degrees to +97 degrees F. The northern coastal Cape Cod climate is influenced by the north to south flow of the large Labrador current and the smaller Cabot current, interacting to form the Cold Wall off of Cape Cod. Some Gulf Stream action is noted though relatively slight. The prevailing winds are from the southwest.

The Cape acts as a huge sandspit jutting out into the Atlantic. It deflects the Gulf Stream eastward away from North Americal and cups the Cold Labrador currents, in its northern shores.

Since the distribution of life in the seas is strongly influenced by temperature, Cape Cod makes the northern-most distribution of many warm temperature water species and the sourthern-most distribution of arctic species. Cape Cod also marks a radical change in the substrate of the shores from sand to rock.

LAND AND WATER USE

Current and Planned Land Use:

Otis AFB, including Camp Edwards Military Reservation, comprises an area of approximately 22,000 acres. It contains the largest contiguous areas of natural Cape Cod habitat left in the state. Slightly more than 3000 acres of the northern portion of the base has been established by the State of Massachusetts (under control of Division of Fish and Game) as Otis AFB Wildlife Management Area. Cape Cod's largest remaining herd of White-tail deer resides in and around the game management area.

Just south of the management area is the Camp Edwards artillery firing range and impact area. Parts of the management area are used as firing positions, especially around Flatrock Hill and other southern hills in the vicinity. Because of stray shots and duds from all the firing positions, parts of the sourthern portion of the Wildlife area are also considered to be in the secondary danger zone for artillery impacts. The management area and Camp Edwards firing range are opened for a very short period each year for hunting. There is no hunting in the primary impact danger zone, however.

Three recent plans have been prepared by the Joint Commission on Federal Base Conversion (JCFBC), Otis Task Force, for possible future uses of the facilities and property at Otis. The JCFBC has proposed using the surplus base housing on Otis as HEW housing. Recreational Plans (including hunting, swimming, archery and other sports and activities) and a visitor/craft center have also been proposed. Another plan has been proposed by the Veteran's Administration for conversion of an area just north of Deer Horn Hill into a National Cemetery.

The U.S. Department of Transportation has proposed to use a 4.4 mile stretch of the game management area. According to Mr. H.A. Weisner, Massachusetts Division of Fish and Game, the Route 25/28 Environmental Impact Statement has been accepted, and construction may begin within the next two to three years. The proposed Route 25 may be from 2700-3000 feet north of the radar site, depending upon where the radar is positioned on Flatrock Hill, and upon the final alignment of the highway.

Control and policies on current and future land use:

Since the proposed site is on a wildlife preserve owned by Massachusetts (under the auspices of the Division of Fish and Game) and presently controlled by the U.S. Government under lease, Flatrock Hill and the surrounding area is not available except through those agencies. Massachusetts state law requires that any archeological finds be given to the state. Conservationists consider Otis AFB important because of the size of the undisturbed Cape Cod habitat present.

PROBABLE IMPACT OF THE PROPOSED ACTION ON THE ENVIRONMENT

Areas of primary importance are air, noise and water pollution, the hazards posed by microwave radiation and the impact on current and proposed land use. These potential pollution impacts are covered in the body of the PAVE PAWS environmental assessment. Further discussion follows:

Microwave radiation:

In considering Microwave radiation effects, the two primary considerations are the impact of microwave on persons wearing cardiac pacemakers and the impact upon animal activity directly in the radar beam. The cardiac pacemaker problem, in regards to Air Force personnel and civilians working at the site, is adequately resolved by rigorous Air Force standards, which regulate pacemaker quality and microwave operation. Other people using pacemakers will be excluded from the hazard area by the 1000 foot radius safety exclusion fence.

*The PAVE PAWS radar at Otis will generate approximately 3/4 of a megawatt of output. The beam will be 2 - 2 1/2 degrees wide with 2 - 2 1/2 degrees side lobes. At 3000 feet the main beam will generate a power density field of 10 milliwatts per CM^2, which is sufficient to cause biological damage after about 6 minutes of continuous duration. In actuality, the time of maximum safe exposure is substantially greater as the beam intermittently irradiates a particular part of the field for only a fraction of a second. The side lobes accompanying the main beam, will generate the same power density at 300 feet.

*See Appendix VII, para 2-C for clarification

The primary danger from microwave radiation is that it is absorbed by biological tissues and transformed into thermal energy. This thermal energy, when accumulated, can cause defects, such as cataracts, to the lens of the eye.

Direct exposure by the beam to biological organisms is thought to be less dangerous for this particular kind of rapid phased array radar than the conventional sweep radar. Also, the radar will be positioned high enough above the ground so that the beam will not irradiate any near-by land. Thus, although ground-dwelling organisms will not be affected, birds may fly into the direct beam of the radar. The danger to birds is thought to be minimal except at close range. Microwave damage to biological tissue is dependent upon time of exposure and intensity of the beam. At distances beyond 3000 feet, the intensity of the beam is low enough so that the birds will not be injured. Closer than 3000 feet, the birds will not be affected because of very low time of exposure per sweep.

By way of comparison of biological affects, the phased array radar in operation at Eglin AFB, Florida, generates 32 megawatts of power. Birds are so tolerant of it that they can sit on the radar face without noticable harmful effects.

Effects on natural resources development:

There will be an unavoidable impact upon vegetation and wildlife in the immediate area of the installation and the access road leading to it. This impact will consist mainly of vegetation

being cleared for the site and the road which will remove cover and habitat for the wildlife. In addition, salt used for de-icing the road will have an adverse effect, especially upon the acid soil dependent plants in the immediate vicinity of the road. One of these is the blueberry, a wildlife staple. However, considering the area and homogeneity of vegetation involved, this vegetation and soil disruption will be negligible to the entire habitat. There will be slight disruptions of major wildlife activities, such as the migratory corridors, imposed by the site, its fencing, and the access road. The large animals excluded by the radiation buffer zone will have corridors north and south around the area. There will be no foreseeable disruptions of surface water ecology as there is none in the immediate neighborhood. There are no rare or endangered species threatened by the proposed action. Concerning renewable natural resources, vegetation to be cleared consists mainly of homogenous primary habitat used as a game preserve. As such, the economic value of the disturbed forest is negligible and, as mentioned before, due to the vastness of the area, wildlife disruption will also be minimal. There will be a scenic impact which is posed by the prominence of the site. This will be accentuated especially if plans to create a visitor center and a major local area tourist attraction are carried through. Although the danger of soil erosion is low due to the lack of surface drainage within the area, care will

nevertheless be taken in the engineering of the site and its access road because Plymouth sandy loam is easily erodible. Additionally, it would be a good idea if forest management practices could be put into effect in the immediate area of the site. The replacement of the edaphic subclimax genus pitch pine scrub oak with white pine would have the compound effect of reducing the fire hazard, producing more optimum wildlife habitat, and creating a more aesthetic and recreationally productive forest.

Effects on land use present and future:

The Army National Guard will be required to abandon from four to six of its gun positions surrounding the site. This will be necessary because four of the positions are too close to the proposed radar, and use of the other two may disrupt the radar's performance, depending on the structural and operational design characteristics. Since the radar site will be in a Wildlife management area, restrictions placed on future development of the area due to the radar site are surpassed by those restrictions involved in preserving the management area. Access to the area by developers is controlled by the state. The loss of habitats covering the site and egress will not significantly affect the overall habitat, due to size and homogeneity of the area.

The radar site should have few effects on State Route 6 and 25. Both routes would be outside of the 1000 feet cardiac pacemaker safety range for scattered radiation and should remain below the direct beam of the radar to avoid any other hazard. The radar site will be

visible from both routes so that it will have some negative scenic and asthetic ramifications.

Yearly deer hunting should not be greatly hindered. As long as the danger areas are either fenced or posted, no danger to hunters should occur. Installation of a large exclusion fence around the radar at a radius of approximately 1000 ft. should be adequate to keep both deer and hunters away from the installation.

Parks:

In the immediate area, the only park, as such, is the Shawme Crowell State Forest, across Route 6 from the site. No hazard to the forest or people visiting it is expected because of the lower elevation of the forest and a distance of approximately 4000 ft. from the site.

Archaeological and Historical Sites:

Amelia G. Bingham, curator of the Wampanoag Indiam Museum in Mashpee, Mass., indicates that the area in and around Otis is the historical residence of the Wampanoag Indians. No known digs or archaelogical sites are in the Otis/Camp Edwards area. According to Mr. Weisner, arrowheads have been found in some of the pot holes throughout Otis. In addition, a hermit who had lived in the area made carvings on the Bruce and Nye Stones, which are situated in the quadrant southwest of Flatrock Hill. There should be no danger to these carvings resulting from the PAWS project. Dr. Morris Robin,

State Archaeologist, and Mrs. Bingham would like to be present during construction to record and retain any findings.

Alternatives for site selection:

Figure 2, Appendix I, shows the four sites that have been considered for installation of the PAVE PAWS radar system. While none of these sites can be considered to have a serious adverse impact on the local environmental conditions, Flatrock Hill is considered to be the optimum site with regard to probable environmental impact due to ecological considerations and land use.

Pine Hill: This site is an abandoned radar site and installation of the AF radar site here would have minimal ecological impact. It is, however, not desirable due to current land use in the area. The installation of the AF radar site here would require that the Army discontinue using approximately fifteen gun positions since the north-south road would be made unusable.

Deer Horn Hill: Considerable earth grading and vegetation clearing will be required to establish the radar site at this location. The hill has been used previously for an observation tower and about a half acre of the hill is bare of forest type vegetation. In addition, a major north-south deer corridor would be permanently disrupted by installation of the radar. In subsequent years the radar may pose radiation hazards near the peripheral areas of a planned national cemetery in the general vicinity of Deer Horn Hill.

Benchmark 280 Hill: Use of this site would require removal and relocation of a high tension power line that adjoins the hill.

Flatrock Hill: Flatrock Hill was chosen as the primary site as a compromise between probable impact on ecological conditions and land use. There will be some ecological impact due to removal of approximately 4 acres of a game management area. In addition, the use of 4-6 Army gun positions will have to be discontinued.

Probable Adverse Environmental Effects which Cannot be Avoided:

There will be local removal of vegetation and disruption of wildlife and soil. However, such an impact will be minimum to the total productivity of the Otis land mass since only approximately 4 acres of the total available of 17,000 acres of wildlife habitat will be used.

Some sedimentation due to removal of soil and water run off may occur in potholes during construction. This, however, will be minimized by appropriate construction techniques.

Radiation hazards will occur within the immediate area (1000 ft) of the beam direction. However, with the proposed 1000 ft. exclusion radius around the radar site coupled with strict Air Force regulations regarding operation and maintenance of the site will minimize such hazards.

There will be a slight impact on scenic quality in that the radar site will be conspiciously visible from lower terrain vantage points in the area. However, the site will not block or interfere with any scenic views.

Short Term Vs. Long Term Uses:

Construction of the site will involve short-term uses of the Flatrock Hill environment. These uses will include clearing and grading during construction, air and noise impacts, and increased traffic on the egress to the proposed site. The only long-term uses are expected from the presence of the actual radar site and egress. No development is expected near the site, but the radar will probably be of a permanent or semi-permanent nature. The long term productivity of the land occupied by the radar site will be curtailled for the duration of the system.

Irreversible and irretrievable commitments of resources, including facilities, parking lots, and access road:

To construct the proposed radar site, a commitment of natural resources will be necessary. These natural resources will include both renewable resources, in the form of pitch pine/scrub oak woodland, and essentially non-renewable resources, those being primarily grading the hill, etc. Considering the clearing and grading that will be required and the homogeneity of the area, and assuming that the surrounding area will be maintained in its natural state, the total commitment of resources to construct the radar site and supporting facilities is not considered significant. (Estimated at 4 acres).

Since commercial and governmental development is not expected on the access road or on the site, further commitment of resources is not expected. Thus, loss of a small amount of Cape Cod's natural resources is expected in building the site, but no losses are expected after the initial commitment.

ATTACHMENT 1

MICROWAVE RADIATION EFFECTS ON MIGRATORY BIRDS

There have been, in the past few years, studies conducted on different methods of dispersing flocks of birds from their flight pattern in order to eliminate the increasing incidence of bird strikes around airfields. One such study involves the use of a low intensity microwave field within the slightly thermal range of from 10-50 mw/cm^2 of continuous exposure. According to Dr. V. A. Tanner[1] birds will avoid microwave radiation. There are certain reactions the birds will exhibit during laboratory test situations including attempted flight, disturbance in eating habits, and certain impairments in motor activity. These reactions were variable according to the time and direction of exposure. The rational is that these reactions are initiated by the microwave radiation itself and not by heat accumulation.[1,2,3]

According to this evidence, our judgement is that these migrating birds will avoid the radar proposed at Otis AFB and therefore the radar should not pose any threat to avian species. Any birds attempting flight near the radar beam will avoid it and any birds coming into a close distance (from an area not included in the sweep of the radar) should not be harmed even though the beam intensity is greater than 10-50 mv/cm^2. The reason this is true is because this type of radar is a rapid sweep, phased array system which minimizes the exposure to the bird. In conclusion we feel that there will be no probable harm to migratory species from the radars.

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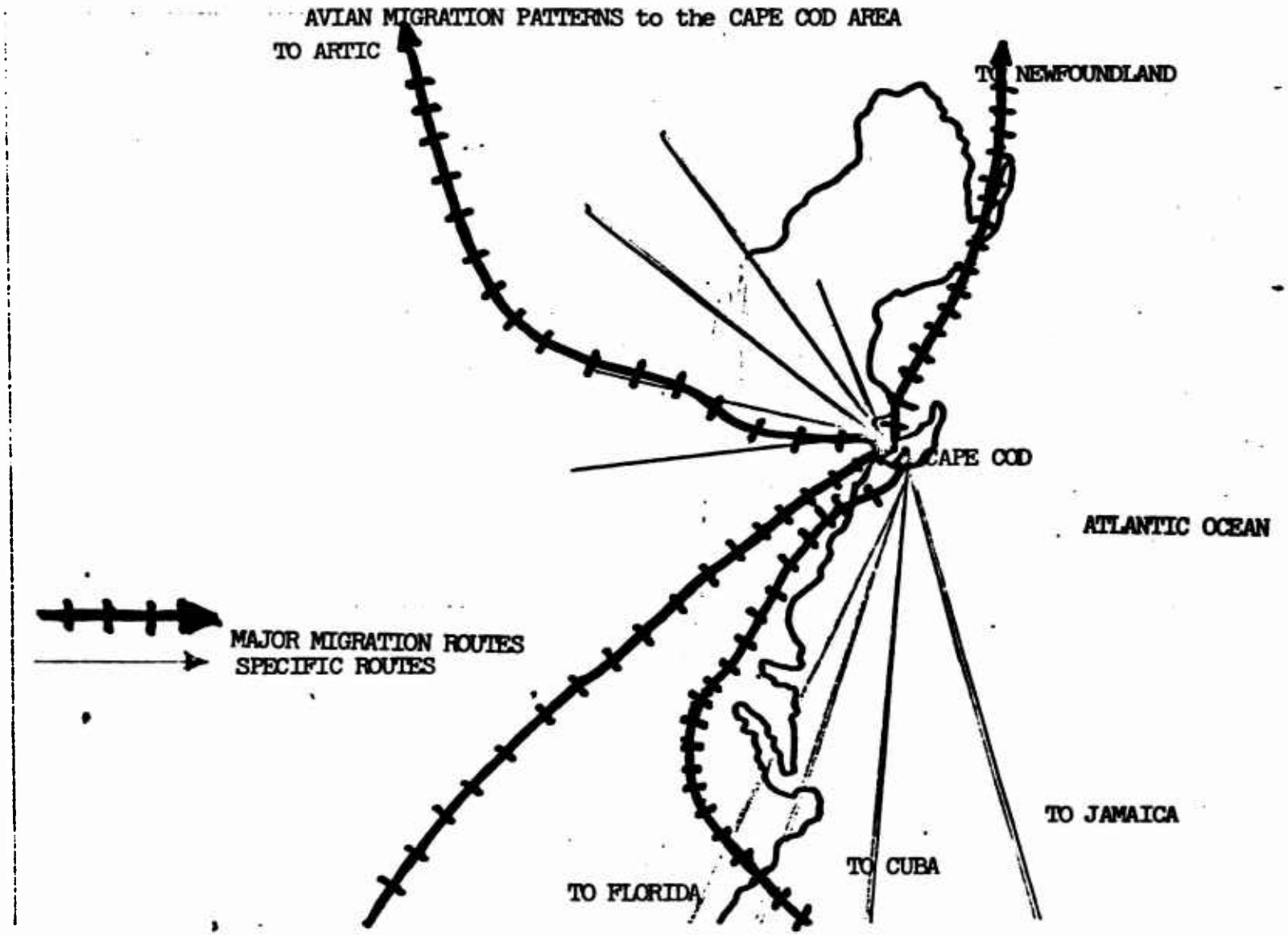

AVIAN MIGRATION PATTERNS to the CAPE COD AREA
TO ARTIC
TO NEWFOUNDLAND
CAPE COD
ATLANTIC OCEAN
MAJOR MIGRATION ROUTES
SPECIFIC ROUTES
TO JAMAICA
TO CUBA
TO FLORIDA

A LIST OF THE MIGRATORY BIRDS OF OTIS AFB

	Common Name	Scientific Name	Season* and Habitat**
1.	Holboell's Grebe	Colymbus holboelli	F&S C
2.	Horned Grebe	Colymbus auritus	F&S C
3.	Loon	Gavia immer	Su C
4.	Black Guillemot	Cepphus gryle	W C
5.	Brunnich's Murre	Uria lomuia	W C
6.	Razor-billed Auk	Alca forda	W C
7.	Dovekie	Alle alle	W C
8.	Pomarine Jaegar	Stercorarius pomarinus	S C
9.	Parisitic Jaegar	Stercorarius parasiticus	F&S C
10.	Kittiwake	Rissa tridactyla	W C
11.	Glaucous Gull	Larus hyperboreas	W C
12.	Iceland Gull	Larus leucopterus	W C
13.	Kumlien's Gull	Larus kumlienii	W C
14.	Great Black-backed Gull	Larus morinus	F&S C
15.	Roseale Tern	Sterna dougalli	Su C
16.	Corys Shearwater	Puffinus borealus	F C
17.	Leach's Petrel	Oceanodroma leucorhoa	Su&F C
18.	Wilson's Petrel	Oceanites oceanicus	Su C
19.	Gannet	Moris bassana	F&S C
20.	Double-crested Cormorant	Phalacrocorax auritus	F&S C
21.	Merganser	Mergus americanus	Su C
22.	Baldplate	Mareca americana	W IW
23.	Green-winged Teal	Nettion carolinense	W IW
24.	Blue-winged Teal	Querquedula discors	F IW
25.	Shoveler	Spatula clypeata	W IW
26.	American Pintail	Dafila acuta	W IW
27.	Wood Duck	Aix sponsa	W IW
28.	Canvasback	Marila valisneria	W C
29.	Scaup Duck	Marila marila	W C
30.	Golden-eye	Glaucienetta clangula	F&S C
31.	Bufflehead	Charitonetta albeola	W C&IW
32.	Old-squaw	Clangula hyemalis	F&S C

Common Name	Scientific Name	Season* and Habitat**
33. King Eider	Somateria spectabilis	W C
34. Scoter	Oidemia americana	Common C&IW
35. Surf Scoter	Oidemia perspicillata	Common C
36. Ruddy Duck	Erismatura jamaicensis	Common C
37. Canada Goose	Branta canadensis	Common IW
38. Brant	Branta bernicula	W IW
39. Bittern	Botaurus lentiginosus	W IW
40. Great Blue Heron	Butorides virescens	Common IW
41. Egret	Casmerodus egretta	Su IW
42. King Rail	Rallus elegans	Common IW
43. Virginia Rail	Rallus virgianianus	W IW
44. Northern Phalarope	Lobipes loatus	Common IW
45. Dowitcher	Limnodromus griseus	F C
46. Stilt Sandpiper	Micropalama himantopus	F C
47. Knot	Calidris canutus	Common C
48. Purple Sandpiper	Arguatella maritima	F&W C
49. Bairds Sandpiper	Pisobia bairdi	F C
50. Least Sandpiper	Pisobia minutilla	Common C
51. Semipalmated Sandpiper	Ereunetes pussilus	Common C
52. Sanderling	Crocethia alba	Common C
53. Greater Yellow Legs	Totanus melanoleucus	Common C
54. Yellow Legs	Totanus flavipes	F C
55. Solitary Sandpiper	Tringa solitaria	Common C
56. Western Willet	Catoptrophorus semipalmata	F C
57. Spotted Sandpiper	Actitus macularia	Common C
58. American Black-bellied Plover	Squatorola squatorola	Common IW
59. Killdeer	Charadrius Vociferous	Common IW
60. Semipalmated Plover	Charadrius semipalmatus	Common IW
61. Ruddy Turnstone	Arenaria interpres	Common F
62. Marsh Hawk	Circus hudsonius	Common F
63. Red-shouldered Hawk	Buteo lineatus	Common F
64. Broad-winged Hawk	Buteo platypterus	Common F

Common Name	Scientific Name	Season* and Habitat**
65. Duck Hawk	Falco peregrinus	Rare F
66. Pigeon Hawk	Falco columbarius	Common F
67. Osprey	Pandion haelaetus	Common C&F
68. Short-eared Owl	Asio flammeus	Common C&F&IW
69. Nighthawk	Chordeiles virgianus	Common F
70. Chimney Swift	Chaetora pelagica	Common F
71. Ruby-throated Hummingbird	Archiloches colubris	Common F
72. Kingbird	Tyrannus tyrannus	Common F
73. Phoebe	Sayornis phoebe	Common F
74. Wood Pewee	Myiochanes virens	Common F
75. Horned Lark	Otocoris alpestris	Common F
76. Bobolink	Polichonyx oryzivorus	Common F
77. Cowbird	Molothrus ater	Common F&C
78. Red-winged Blackbird	Agelaius phoeniceus	Common F
79. Eastern Meadowlark	Sturnella magna	Common F&C
80. Rusty Blackbird	Euphagus carolinus	Common F&IW
81. Pine Grosbeak	Pinicola enucleator	W F
82. Crossbill	Loxia curvirostra	W F
83. Redpoll	Acanthus linaria	W F
84. Goldfinch	Astragalinus tristus	Su F
85. Pine Siskin	Spinus pinus	W F
86. Vesper Sparrow	Poecetas gramineus	Common F
87. Ipswich Sparrow	Passerculus pinceps	Common F
88. Savannah Sparrow	Passerculus sandwichensis	S F&C&IW
89. Sharp-shinned Sparrow	Passerbules caudacutus	Common F&C
90. White-throated Sparrow	Zonatrichia albicollis	Common C
91. Tree Sparrow	Spizella monticola	Common C
92. Chipping Sparrow	Spizella passerina	Common F
93. Field Sparrow	Spizella pusilla	Common F
94. Swamp Sparrow	Melospiza georgiana	Common F&IW
95. Fox Sparrow	Passerella iliaca	Common C
96. Scarlet Tanager	Piranga erythrmelas	Common F

Common Name	Scientific Name	Season*	and Habitat**
97. Cliff Swallow	Petrochelidon lunifrons	Common	F
98. Barn Swallow	Hirundo erythrogatra	Common	F
99. Bank Swallow	Riparia ripari	Common	F&IW
100. Red-eyed Vireo	Vireosylva olivacea	Common	F
101. Blue-eyed Vireo	Laaivireo solitarius	Common	F
102. Black and White Warbler	Miniotilta varia	Common	F
103. Golden-winger Warbler	Vermivora chrysoptera	Common	F
104. Nashville Warbler	Vermivora ruficappilo	Common	F
105. Northern Parula Warbler	Compsothlypis americana	Common	F
106. Yellow Warbler	Dendroica aestiva	Common	F
107. Black-throated Blue Warbler	Dendroica caerulescens	Common	F
108. Myrtle Warbler	Dendroica cornata	Common	F&C
109. Chestnut-sided Warbler	Dendroica pennsylvania	Common	F
110. Black-throated Green Warbler	Dendroica virens	Common	F
111. Pine Warbler	Dendroica vigosi	Common	F
112. Prairie Warbler	Dendroica discolor	Common	F&C
113. Oven-bird	Seiurus aurocapillus	Common	F
114. Maryland Yellow-throat	Geothlypis trichas	Common	C&IW
115. Canada Warbler	Wilsonia canadensis	Common	F
116. Redstart	Setophaga ruticilla	Common	F
117. Pipit	Anthus rubescens	F	C&IW
118. Brown Creeper	Certhia familiaris	Common	F
119. Red-breasted Nuthatch	Sitta canadenensis	F&W	F
120. Veery	Hylocichla fuscescens	Common	F
121. Olive-backed Thrush	Hylocichla ustulata	Common	F

* W - Winter
S - Spring
Su - Summer
F - Fall

** F - Forest
C - Coast
IW - Inland Waterways

APPENDIX V

ELECTROMAGNETIC RADIATION REPORT

FOR PAVE PAWS

JULY 1975

REVISED SEPTEMBER 1975

ELECTROMAGNETIC RADIATION REPORT

FOR PAVE PAWS JULY 1975

REVISED SEPTEMBER 1975

1.0 ELECTROMAGNETIC RADIATIONS.

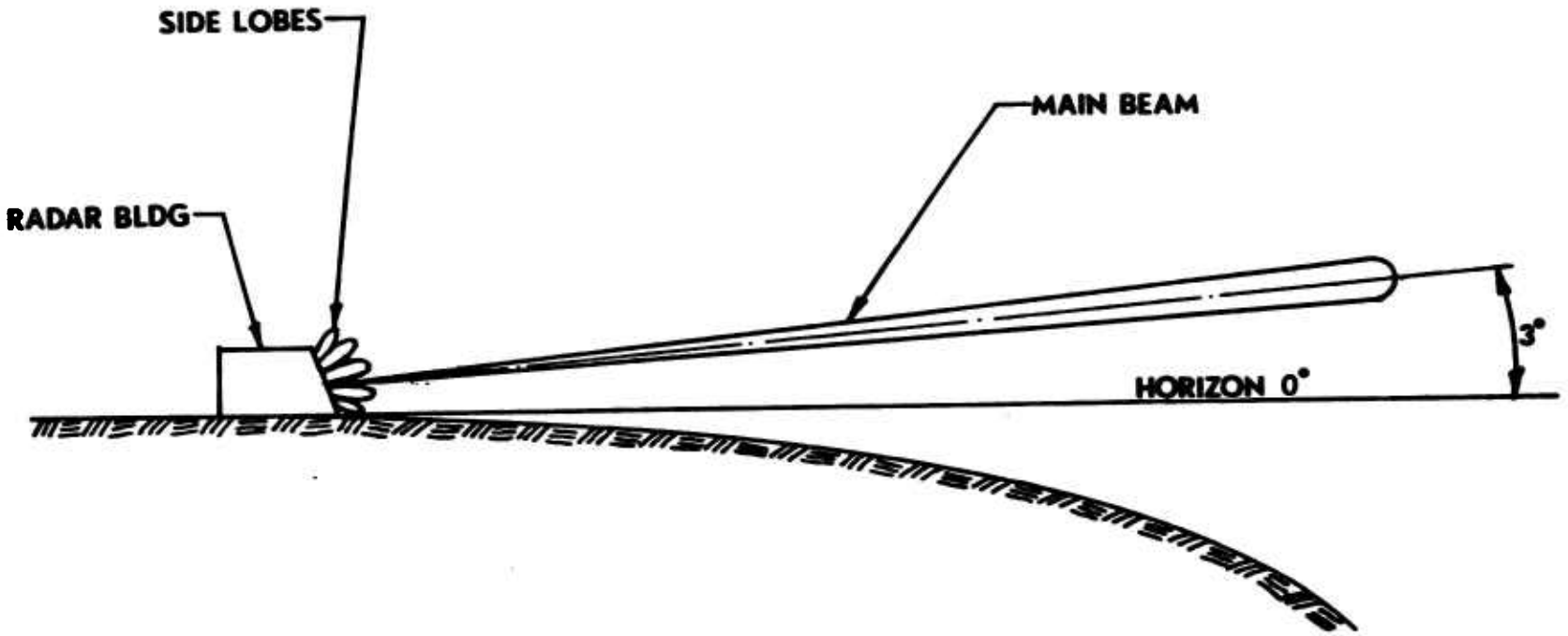
1.1 Radiation Characteristics. The PAVE PAWS is a phased array radar system that radiates its energy over a limited direction in azimuth and elevation. The radar antenna having two faces, is capable of directing a narrow pencil-like beam a total of 240° in azimuth and from 3° to 85° in elevation. The main beam will be in constant motion at all times stroboscopically sweeping 240° in azimuth during the surveillance mode between 3° and 10° in elevation and illuminating points in space up to 85° in elevation throughout azimuth during the tracking mode or space object identification mission.

Associated with the main beam are sidelobes that extend about the main beam and are at least 100 times less in magnitude. Figure 1 portrays the radar beam during the surveillance mode. Although the main beam will clear permanent obstructions such as buildings, towers, trees, roads, etc., the sidelobes radiate at many angles with respect to the main beam resulting in some radiation near and along the ground. Since the main beam has a finite beam width (about 2°), the nose of the beam must be at a sufficient elevation above the ground to allow formation of the beam and also to clear obstructions on the ground. The main beam elevation will be tailored to meet the local topography and will never be allowed to radiate along the ground or to illuminate obstructions.

The minimum elevation angle will depend upon the final design of the antenna and the local terrain and will be fixed at this installation for all conditions of operation. The beam will be controlled by a computer program which will not allow main beam operation at an elevation angle lower than that required for operations. If the main beam were allowed to radiate into the ground by operating at less than the minimum elevation angle, the beam would not form properly and would impact the accuracy and detection capability of the system. Thus, the main beam will always be above the horizon and there will always be a sidelobe along the ground regardless of the main beam elevation.

Figure 2 portrays the radar beam during the tracking mode or space object identification while performing surveillance and demonstrates how sidelobes can illuminate the ground for any elevation of the main beam.

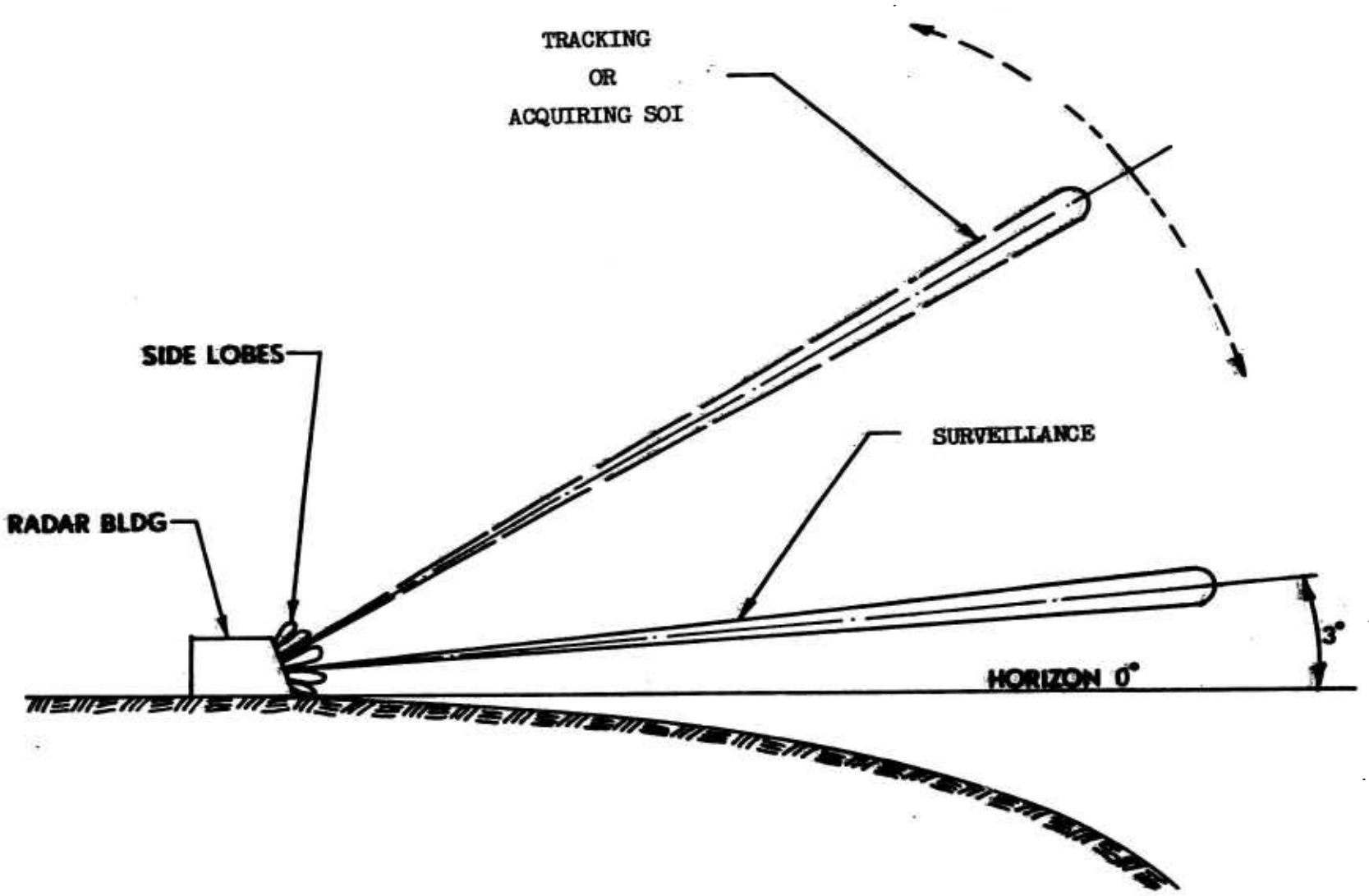
Due to the lower effective radiated power, the field strength of the sidelobes rapidly decreases to non-interferring levels outside the radar operations area. The dwell time for any target illuminated by sidelobes is greater than that for the main beam since sidelobes radiate in many directions from the main beam resulting in a continuous in and out of sidelobe radiation as the main beam performs its scanning function.



SIDE VIEW · RADAR BEAM

DURING SURVEILLANCE MODE

APPENDIX - 5
Figure 1



SIDE VIEW · RADAR BEAM

DURING TRACKING AND SURVEILLANCE OR SOI MODE

APPENDIX-5
Figure 2

Because sidelobes occur at ground level for almost any position of the main beam, they are examined for Electromagnetic Compatibility (EMC) with objects or equipments on the ground such as personnel, electro-explosive devices (EED), fueling operations, cardiac pacemakers and electronic equipments capable of receiving or transmitting electromagnetic energy. Aircraft flying in the vicinity of the site can encounter the main beam and this occurrance is also examined for Electromagnetic Compatibility (EMC) with the PAVE PAWS.

1.2 Electromagnetic Effects - can influence the environment in two basic ways:

1.2.1 Electromagnetic Interference (EMI) - can be caused by natural phenomena such as atmospheric conditions, precipitation static or from extraterrestrial sources such as the sun and stars. Man-made objects such as radar transmitting systems can create interference to other electronic receiving systems if the frequency and field strength due to the transmitting source are within the sensitivity domain of the receiver resulting in an undesired signal that could interfere with its normal operation. In addition, intense electromagnetic energy can cause temporary desensitization of electronic equipment regardless of the radio frequency. This is known as "High Power Effect" (HPE). When the intense electromagnetic field is removed, the electronic equipment returns to its original condition. Typical of electronic equipment that could be affected by electromagnetic interference are radar systems, navigational aids, radio receivers, TV sets, tranceivers, hi-fi equipment and hearing aids. Attachment 1 lists all sources of electronic equipments and installations that are considered for

electromagnetic interference between the PAVE PAWS and its environment both on Otis AFB and in the surrounding area.

1.2.2 Radiation Hazards - are concerned with the deleterious effects of electromagnetic energy on animal life, volatile fuels, ordnance equipment and electronic devices. Specifically, these hazards are grouped in accordance with the following categories for which EMC criteria has been established.

*1.2.2.1 Biological Effects. The criterion for this effect is 10mw/cm^2 and is verified in several documents. These include the following:

a. AFM 161-7 - Control of Hazards to Health from Microwave Radiation - Dec 65

b. T.O. 31Z-10-4 - Electromagnetic Radiation Hazards - 1 June 1971

c. USA Standard Safety Level of Electromagnetic C95.1-1966 Radiation with Respect to Personnel

The latest Air Force document on biological hazard control is AFR 161-42, Radar Frequency Radiation Health Hazard Control which supersedes AFM 161-7. It lists the criterion as 10mw/cm^2 for 6 minutes or greater. Exposures of less than 6 minutes are subject to a criterion of 3600 mw sec per cm^2 allowing for greater exposure to radiation for shorter periods of time. AFR 161-42 has been used as the regulating criteria for this study.

*See Appendix VII para 2a for clarification.

1.2.2.2 Fuel Hazards. Technical Manual T.O. 31Z-10-4, "Electromagnetic Radiation Hazards", lists a safe peak power density of 5 watts/cm^2 in areas for refueling operations. All areas in which the peak power density exceeds this value are considered unsafe for this purpose.

1.2.2.3 Ordnance Hazards. Air Force Manual 127-100 entitled, "Explosive Safety Manual", as modified by Aeronautical Systems Division, lists the following criteria for electroexplosive devices (EED's).

a. 100 w/m^2, average power for:

1. EED's stored or transported in metallic cans or containers.

2. Airborne weapon systems with external explosive loads not in attack mode.

3. Shipments of transportation packaged or configured EED's or explosive items containing EED's being moved inside aircraft.

b. 6.63 w/m^2, average power, for taxiing an airborne aircraft with wheels down having external explosives loads where such ordnance subsystems are not in the attack mode.

c. For distance between any unshielded EED and radiating source:

Criterion is $D = \frac{450}{f}\sqrt{Pt\ G}$

Where D = Distance in feet

Pt = Peak radiated power, watts

G = Antenna gain

f = Frequency in megacycles

d. 100 w/m^2 average power, for shielded EED's in transport.

*1.2.2.4 Cardiac Pacemaker

Criterion: 200 Volts/meter, peak,

5 successive beat, duration

Cardiac pacemakers are susceptible to electromagnetic energy in several ways and can cause the wearer to lose consciousness if the interference persists. The frequency & duration of radiation, power density and rate in which the energy is applied (pulse repetition rate) are important in determining the susceptibility of the pacemaker. The School of Aerospace Medicine has recommended a maximum value of 200 volts/meter (peak) of electromagnetic environment for the cardiac pacemaker. The duration of the exposure must also be sufficient to cause a loss of 5 successive beats for the effect to be significant. Because of the duration criteria, only sidelobe radiation is of concern.

1.2.2.5 Receiver Burnout

Criterion: 325 mw, peak power

This effect is a frequency sensitive phenomenon which will permanently affect the front end of a receiver tuned to the same frequency as the transmitting device, due to the excess radio frequency power absorbed by this circuit.

1.2.2.6 Minimum Safe Distances

Minimum safe distances for all types of radiation hazards were calculated using the criteria previously described for the radar technical parameters. These are shown in attachment 2. Radiation was assumed to be continuously exposing the target for both main beam and

*See Appendix VII para 2b and 2c for clarification

sidelobe considerations. When main beam illumination is considered, the effect of the radiation is not continuous due to the short pulse width and the random and sporadic nature of the beam. An aircraft, for example, would receive a single burst of RF illumination only once during a radar scan interval and this process would only be repeated approximately every 12 seconds. For this reason biological and cardiac pacemaker radiation effects due to main beam illumination become minimal when considered in the light of exposure time. A chart showing determination of flight restrictions due to main beam effects is also included in attachment 2.

1.3 Electromagnetic Radiation Effects Prevention. To prevent the occurrence of electromagnetic interference and radiation hazards in the local environment, careful attention has been given to choice of location, design parameters, frequency allocation, emission bandwidth and power levels of the radar system. The radar has been sited to assure that the minimum safe distances required to prevent Radiation Hazards are achieved. Where appropriate, fences and/or signs will be installed. Electromagnetic radiations from PAVE PAWS will be carefully controlled by performance monitoring and calibration equipments to insure that they remain within specification. The subsystems and equipments that constitute PAVE PAWS shall conform to appropriate military standards and specifications which will assure electromagnetic compatibility both internally to the system itself and to other systems external to PAVE PAWS. Testing of the subsystems and equipments will assure that the operational system is compatible with itself and to other equipments in the area. Actual field

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measurements will be made to verify power density calculations for minimum safe distances of radiation hazards. A preliminary analysis of the EMC impact of PAVE PAWS on the surrounding environment was performed by the Electromagnetic Compatibility Analysis Center and is contained in Attachment 3.* Studies made of the electromagnetic radiation effects on Otis AFB indicate that there will be no electromagnetic interference or radiation hazards associated with this system if the 1000 ft buffer zone is utilized and distances as listed in Attachment 2 are not exceeded. In the case of receiver burnout, the PAVE PAWS assigned operating frequency, harmonics and subharmonics thereof, will be selected to prevent direct frequency coupling to other receivers in the area.

**1.4 Electromagnetic Radiation Effects Consultants. The Systems Program Office is supported by the Department of Defense Electromagnetic Compatibility Analysis Center (ECAC) which provides electromagnetic compatibility (EMC) consultation to the program. ECAC will monitor the contractors EMC design and provide information during program design reviews to assure that the required standards are being followed. Using their existing data bank, ECAC will identify and describe potentially vulnerable equipments that are operating in the area of the PAVE PAWS site. A study of assigned operating frequency will be made and verified by the local frequency coordinator office to assure frequency compatibility with the local environment.

The School of Aerospace Medicine (SAM), Brooks Air Force Base also supports the Systems Program Office in the radiation hazards area by performing susceptibility studies of cardiac pacemakers to existing high

*Revision 2 for baseline system; Revision 3 for growth option.
**See Appendix VII for clarification

powered phased array radars and provides current assessment of the latest criterion. It has and will continue to study the biological hazard and application at the PAVE PAWS frequencies and has provided explicit data to corroborate the existing biological hazard criterion.

1.5 Conclusions on the Effects of Electromagnetic Radiations.

The electronic equipments in and around Otis AFB listed in Attachment 1 were examined for possible mutual electromagnetic interference with PAVE PAWS with the finding that such interference will not occur provided that the radar frequency assignment is based on the avoidance of fundamental or harmonic frequencies of the existing equipment. High power effect is possible to any unshielded electronic equipment in the near vicinity of PAVE PAWS at a distance of 3275 ft or less (assuming worst case condition) but the siting of the system is sufficiently remote from traveled roads, housing area, runways, etc., that this effect should not occur except in the mainbeam for aircraft. Furthermore, all electronic equipment has some inherent shielding due to its cabinet, chassis, and being installed within a building or vehicle, so that actually the effect will be much less than indicated.

Radiation hazards were examined for each of the effects described previously and because of the location of PAVE PAWS and its distance to personnel, housing areas, refueling operations and electro-explosive devices, no difficulty is anticipated. A security fence 1000 feet from the radar antenna will be erected to eliminate the possibility of personnel wearing cardiac pacemakers entering a potentially hazardous area. This will also prevent other personnel and many wildlife from entering this same area.

Persons with cardiac pacemakers flying in the vicinity will not encounter a hazardous situation.

An evaluation of local air traffic for radiation hazards is contained in attachment 4. This evaluation is updated below.

*A. Ref Atch 4, page 3, para c. The School of Aerospace Medicine advises that five successive beats of the pacemaker must be interfered with to create a significant effect. The 200 V/meter criteria is established for an area where radiation is relatively constant as in the sidelobes. Within the critical distances established for 200 V/meter in the main beam the duration criteria governs. Therefore, there is no significant effect to cardiac pacemaker passengers on board aircraft and flight restrictions are not required.

B. Ref Atch 4, page 3, para e. Overflight is not applicable to the Flatrock site.

*C. Ref Atch 4, page 7 para f. Criteria is no longer applicable. AFM 167-1 has been superseded by AFR 161-42. Conclusion is valid.

D. Ref Atch 4, page 7, para g&h. The selection of Flatrock Hill eliminates any significant VFR traffic pattern deviations because of "high power effects" and EEDs.

*See Appendix VII for authoritative criteria

The data involving hazards criterion and HPE interference indicate that no major disruption of normal air traffic patterns in the vicinity of Otis AFB would occur if PAVE PAWS were deployed at Otis AFB.

Military notams will be published to preclude aircraft carrying EED's from approaching the facility. Separation distances are approximately 3800 ft for aircraft in the "All Up" configuration and 2.42n miles for aircraft in the "wheels down" configuration.

ATTACHMENT 1

SOURCES OF ELECTROMAGNETIC INTERFERENCE

A. All sources of possible Electromagnetic Interference (EMI) between PAVE PAWS and its environment in the Otis area which have been considered are listed below:

1. Commercial Radio and Television Stations. The following stations broadcast within the local area.

FREQUENCY	STATION CALL	LOCATION
TV		
82-88 MHz	WTEV (Channel 6)	New Bedford
RADIO		
1240 KHz	WOCB	W. Yarmouth
1340 KHz	WNBH	New Bedford
1390 KHz	WPLM	Plymouth
1420 KHz	WBSM	New Bedford
1170 KHz	WVLC	Orleans
104.7 MHz	WVLC	Orleans
97.3 MHz	WGCY	New Bedford
98.1 MHz	WMYS	New Bedford
94.9 MHz	WOCB	West Yarmouth
99.0 MHz	WVOI	Martha's Vine-Yard
99.1 MHz	WPLM	Plymouth
101.9 MHz	WCIB	Falmouth
106.1 MHz	WCOD	Hyannis
99.9 MHz	WQRC	Barnstable

2. Radio Links. The following communications links exist in the local area.

AGENCY	TYPE	FREQUENCY	USE
USCG	Radio	VHF/UHF	Air to Ground
USCG	Radio	HF (2-12 MHz) (also 400 KHz rescue 500 KHz	Communications from Manomet to Western North Atlantic and the Great Lakes area.
USCG	Microwave	Trans: 1812 MHz Recv: 1776 MHz	8 channel link to Manomet, connecting to US Coast Guard station. This link controls the HF transmitters at Manomet.
USCG	Microwave	Trans: 1739 MHz Recv: 1711 MHz	8 channel link from Manomet to Marshfield
ANG	Radio	VHF/UHF	Air to Ground
ANG	Radio	HF	Emergency assistance to Cape Cod fire departments.
ADC	Microwave	3700-4100 MHz	SAGE LINE on station originating in N. Truro, and linked via Sandwich.
Command Post	Radio	UHF	Emergency Net
Base Units	Radio	FM	Security, Crash and Fire, Taxi, etc.
AT&T	Microwave	3.710-4.170 GHZ	Line of Sight Microwave Link

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3. Landing and Navigational Aids at Otis AFB.

AGENCY	TYPE	FREQUENCY	USE
FAA	AN/ASR-5	S-Band	Airport Surveillance
FAA	ILS	UHF	Approach
FAA	TACAN	1192 MHz (Channel 105)	Approach
ANG	AN/TPN-16	X-Band	Ground Control Approach.
Hyannis	TACAN	1181 MHz (Channel 94)	Approach

4. Radar System at Otis AFB.

AGENCY	TYPE	FREQUENCY	USE
USCG	AN/APS-31	X-Band	Shop Maintenance Facility
USCG	AN/APN-95	X-Band	Shop Maintenance Facility
ARMY	AN/MPQ-4	X-Band	Mortar Location

5. Airborne Equipment utilized by Aircraft at Otis AFB.

AGENCY	TYPE	FREQUENCY	USE
USCG	AN/APS-31	X-Band	Search
USCG	AN/APN-95	X-Band	Navigational Aid
ANG	(F-106)	X-Band	Fire Control System
ALL	ALL	HF/VHF/UHF	Air to Ground

6. Residentail/Commercial Equipment. There are numerous television sets, radios, and other home electronic equipment, both on-base and in the surrounding residential areas.

7. Commercial Communications Radio in the Area. The following frequency bands are utilized by the public or specific government agencies.

USER	FREQUENCY
Fire, Police, Public (For profit) such as Taxis, Oil Trucks, etc., State Communications Systems.	450-470 MHz 406.1-420 MHz
Public Safety Agencies	470-512 MHz
Commercial Vehicles	150-163 MHz
Marine Usage including Commercial Shipping	156-158 MHz
Citizens Band	26.965 - 27.255 MHz

ATTACHMENT 2

BASELINE SYSTEM

A. Radar Parameters: The technical parameters for the proposed radar are listed below:

Type of Transmitter	Solid State
Peak Power	700KW
Antenna Gain (db) Max	39db
Average Power	140KW
Duty Cycle	0.2
Sidelobe (db down)	20
Frequency	425-450MHz
Surveillance Mode	40% radiated power requirement
Tracking/SOI mode	60% radiated power requirement

B. Minimum Safe Distances for Radiation Hazards.
These parameters have been used to construct a table of minimum safe distances for radiation hazards from the criteria as previously described. A main beam and sidelobe exposure are calculated. The sidelobes, having much lower effective radiated power than the main beam, result in smaller minimum safe distances. This will apply to objects being illuminated on the ground. Aircraft will be exposed to radiation from the main beam and, therefore, will be appropriately restricted from flying too close to the PAVE PAWS radar.

a. Biological Effect

Main Beam $\geq$ 6 minutes	2050ft.
Sidelobe	265ft.

Exposure times of less than 6 minutes are computed in accordance with AFR 161-42 which gives criterion of 3600MW sec, per cm^2. For example, exposure to 0.5 sec. of radiation results in criterion of $3600/0.5 = 7200$ MW/cm^2. This gives radiation hazard distance of 80ft. for main beam.

b. Fuel Hazard

Main Beam	290ft.
Sidelobe	30ft.

c. Ordnance Hazards

Electroexplosive devices, under the following conditions:

1. For EED's stored or transported in metallic cans or containers.

2. For airborne weapon systems with external explosives loads, not in attack mode.

Main Beam	2050ft.
Sidelobe	Not applicable

3. For taxiing aircraft and airborne aircraft with wheels down having external explosives loads where such ordnance subsystems are not in the attack mode.

Main Beam	7940ft.
Sidelobes	1030ft.

4. For the distance between any unshielded EED and radiating source:

Main Beam	Not applicable
Sidelobe	1.14n.miles

5. Shielded EED's in transport:

Main Beam	2050ft.
Sidelobe	265ft.

d. Cardiac Pacemaker*

Main Beam	1.02n.mi.
Sidelobe	625ft.

*Time element - loss of 5 successive heart beats considered clinically significant. Due to sporadic motion of main beam this cannot occur. Also, inherent shielding provided by aircraft (15db) reduces main beam hazard distance to 1100ft.

e. Receiver Burnout

Main Beam	6.77nmi
Sidelobe	4225ft.

f. High Power Effect*

Main Beam	3.33nmi
Sidelobe	2030ft.

*These distances are for unshielded equipment. Actually, the chassis and aircraft skin will provide a minimum of 25db attenuation from main beam radiation reducing hazard distance to 1140ft. For sidelobe radiation, chassis and vehicle attentuation (20db) will reduce hazard distance to 205ft.

DETERMINATION OF FLIGHT RESTRICTIONS DUE TO MAIN BEAM EFFECTS

EFFECT	CONCLUSION
Biological <6 min.	No restriction required. Random nature of beam precludes the prolonged illumination required for this effect.
Fuel	No restriction required. Applicable only to refueling operations.
EED's "All Up"	Restriction required. Determined by AFM 127-100 procedures. Implemented by Military Notam (Approx 2050ft.)
EED's "Wheels Down"	Restriction required. Determined by AFM 127-100 procedures. Implemented by Military Notam (Approx 7940ft.)
High Power	No restriction required. Random nature of beam precludes any significant effect on flight safety or navigation equipment. Shielding provided by aircraft skin and equipment chassis reduce hazard distance to insignificant value.
Cardiac Pacemaker	No restriction required. Random nature of beam precludes prolonged exposure which is necessary to cause hazardous effect. Shielding provided by aircraft skin reduces hazard distance to insignificant value.

GROWTH OPTION

MINIMUM SAFE DISTANCES FOR RADIATION HAZARDS

A. Radar Parameters: The technical parameters for the proposed radar are listed below:

Type of Transmitter	Solid State
Peak Power	1300 KW
Antenna Gain (db) Max	40 db
Average Power	260 KW
Duty Cycle	.2
Sidelobe (db down)	20.0
Frequency	425-450MHz

Surveillance mode: 40% radiated energy required.

Tracking/SOI mode: 60% radiated energy required.

B. Minimum Safe Distances for Radiation Hazards. These parameters have been used to construct a table of minimum safe distances for radiation hazards from the criteria as previously described. A main beam and sidelobe exposure are calculated. The sidelobes, having much lower effective radiated power than the main beam, result in smaller minimum safe distances. This will apply to objects being illuminated on the ground. Aircraft will be exposed to radiation from the main beam and, therefore, will be appropriately restricted from flying too close to the PAVE PAWS radar.

a. Biological Effect

Main Beam	$\geq$ 6 min	3790ft.
Sidelobe		490ft.

Exposure times of less than 6 minutes are computed in accordance with AFR 161-42 which gives criterion of 3600MW Sec. per CM^2. For example, exposure to 0.5 sec. of radiation results in criterion of $3600/0.5 = 7200MW/CM^2$. This gives radiation hazard distance of 150ft. for main beam.

b. Fuel Hazard

Main Beam	440ft.
Sidelobe	45ft.

c. Ordnance Hazards

Electroexplosive devices under the following conditions:

1. For the EED's stored or transported in metallic cans or containers.

2. For airborne weapon systems with external explosives loads, not in attack mode.

3. For taxiing aircraft and airborne aircraft with wheels down having external explosives loads where such ordnance subsystems are not in the attack mode.

Main Beam	2.42nmi
Sidelobe	1900ft.

4. For the distance between any unshielded EED and radiating source:

Main Beam	Not applicable
Sidelobe	1.89nmi

5. Shielded EED's in transport:

Main Beam	3790ft.
Sidelobe	490ft.

d. Cardiac Pacemaker*

Main Beam	1.65nmi
Sidelobe	1010ft.

*Time Element, Loss of 5 successive heart beats considered clinically significant. Due to sporadic motion of main beam this cannot occur. Also, inherent shielding provided by aircraft (15db) reduces main beam hazard distance to 1780ft.

e. Receiver Burnout

Main Beam	10.67nmi
Sidelobe	1.1nmi

f. High Power Effect*

Main Beam	5.38nmi
Sidelobe	32 75ft.

These distances are for unshielded equipment. Actually, the equipment chassis and aircraft skin will provide minimum of 25db attenuation from main beam radiation reducing hazard distance to 1850ft. For sidelobe radiation, chassis and vehicle attenuation (20db) will reduce hazard distance to 350ft.

DETERMINATION OF FLIGHT RESTRICTIONS DUE TO MAIN BEAM EFFECTS

EFFECT	
Biological < 6 min.	No restriction required. Random nature of beam precludes the prolonged illumination required for this effect.
Fuel	No restriction required. Applicable only to refueling operations.
EED's "All Up"	Restriction required. Determined by AFM 127-100 procedures. Implemented by Military Notam (Approx. 3780 ft.)
EED's "Wheels Down"	Restriction required. Determined by AFM 127-100 procedures. Implemented by Military Notam (Approx 2.42n. miles)
High Power	No restriction required. Random nature of beam precludes any significant effect on flight safety or navigation equipment. Shielding provided by aircraft skin and equipment chassis reduce hazard distance to insignificant value.
Cardiac Pacemaker	No restriction required. Random nature of beam precludes prolonged exposure which is necessary to cause hazardous effect. Shielding provided by aircraft skin reduces hazard distance to insignificant value.

REFERENCES:

1.	Biological	AFR 161-42 Radar Frequency Radiation Health Control, July 75
2.	Fuel Hazard	T.O. 31Z-10-4, Electromagnetic Radiation Hazards, Pg. 3-20.
3.	Ordnance Hazard	AFM 127-100, Explosives Safety Manual, Change 1, Para 6-22 Also amended by ASD, Directorate of Avionics Engineering.
4.	Cardiac Pacemaker	Recommendation from School of Aerospace Medicine (Mr. J. Mitchell) Brooks AFB.
5.	Receiver Burnout	Recommendation from Electromagnetic compatibility Analysis Center (ECAC Annapolis, MD.

ECAC-CR- 75-052 (Rev. 2)

ATTACHMENT 3

PRELIMINARY ANALYSIS OF EMC IMPACT OF OTIS AFB PAVE PAWS ON THE SURROUNDING ENVIRONMENT

(REVISION 2 - BASELINE SYSTEM)

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Under Contract F-19628-73-C-0031 for the
DEPARTMENT OF DEFENSE
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CONSULTATIVE REPORT

Prepared for

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SECTION 1

INTRODUCTION

BACKGROUND

The U.S. Air Force is planning to deploy the PAVE PAWS phased-array warning system on the east and west coasts of the United States. The mission of the PAVE PAWS system is to detect and track sea-launched ballistic missile (SLBM) attacks on the continental United States and provide the Aerospace Defense Command with credible warning and attack assessment. The Electronic Systems Division (ESD) of the Air Force Systems Command (AFSC) is responsible for the development of the system.

Preliminary planning has been underway since late 1972. Site surveys have been included in that planning. One of the recommended sites is Otis AFB, Massachusetts. Three locations at Otis AFB were under consideration. Two have recently been eliminated. The remaining site under consideration is Flatrock Hill. This report is a preliminary electromagnetic compatibility (EMC) analysis to identify potential EMC problems at Flatrock Hill using the limited specification data presently available.

OBJECTIVE

The objective of this analysis was to identify potential interference to the electromagnetic environment from the PAVE PAWS Radar at the Flatrock Hill site on Otis AFB in Massachusetts.

APPROACH

The electromagnetic environment around the proposed site was determined from ECAC environmental data files. The technical characteristics for the victim receivers were assumed to be typical for each type of receiver in the environment. The technical characteristics of the PAVE PAWS radar were based on the data available in Reference 1.[1]

The effective interference power (P_i) was calculated from the following equation:

$$P_i = P_T + G_T + G_R - L_B - OFR \qquad (1)$$

where

P_T = interfering transmitter power, dBm

G_T = transmitting antenna gain, dBi

G_R = receiving antenna gain, dBi

L_B = propagation path loss, dB

OFR = the amount of attenuation experienced by the interference signal as a result of receiver selectivity characteristics and the power spectral density characteristics of the interference signal, dB.

The effective interference power was compared to an interference threshold for each type of equipment to determine when interference would occur.

---

[1] Phased Array Warning System PAVE PAWS Site Survey Report for East Coast Locations, March 1975.

SECTION 2

ANALYSIS

GENERAL

The parameters of the PAVE PAWS transmitter are given in TABLE 1.

TABLE 1

PAVE PAWS TRANSMITTER PARAMETERS

Peak Radiated Power Kilowatts (dBm)	737/88.7
Pulse Width (Milliseconds)	10
PRF (Pulses per second)	27
Antenna Gain (dBi)	39.4
Antenna Sidelobe Attenuation (dB)	20

Using the data from TABLE 1, the Mason-Zimmerman spectrum for a PØ (pulsed emission) output was derived and is shown in Figure 1. A pulse rise and fall time of 1 microsecond was assumed. The antenna array will be constructed on two faces. The azimuth coverage shall be from 355°T eastward to 235°T (240° total coverage). The radar will search from 3^{o} to 85^{o} in elevation with a beam width of 2^{o}. Therefore the ground will not be illuminated by the main beam.

The analysis was made to determine potential interference to receivers operating within 150 miles of the PAVE PAWS transmitter. Potential interference was investigated for in-band, adjacent-band, and harmonically related receivers. Where possible, the spurious response frequencies of the receiver were also investigated for potential interference. Those equipments specifically investigated were: Line-of-sight (LOS) microwave systems, TACAN systems, UHF amplitude-modulated (AM) air-to-ground and ground-to-air systems, narrow-band FM UHF mobile systems, TV receivers, and radars.

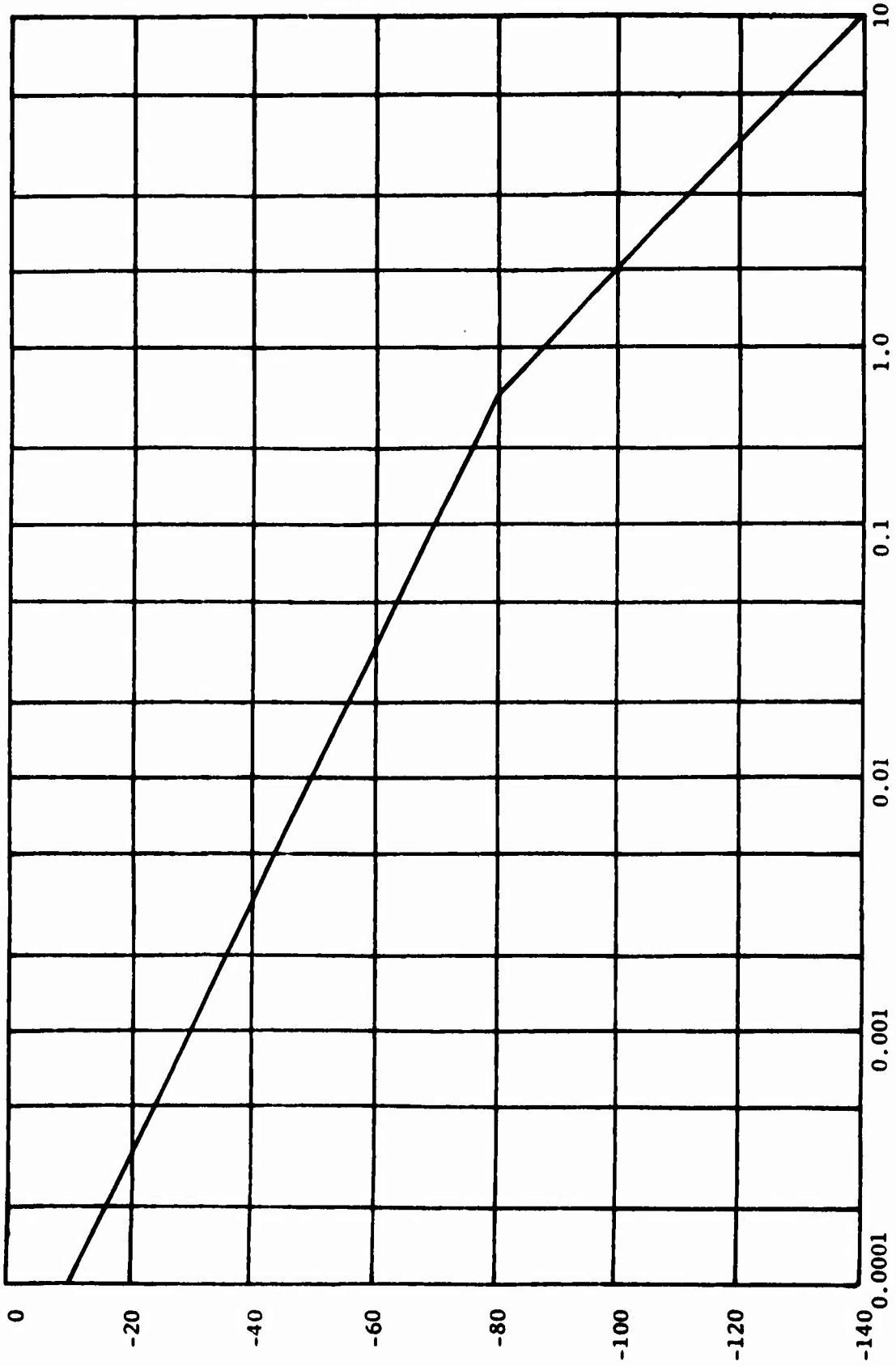

Figure 1. Simulated PAVE PAWS emission spectra.

LOS MICROWAVE EQUIPMENTS

The LOS microwave links in the area around Otis AFB are shown in Figure 2. The links of interest located near the Flatrock Hill site operate in the 3710-4170 MHz frequency band. Interference to the microwave receivers could be produced by the ninth harmonic of the PAVE PAWS. These harmonics would fall within the passband of the microwave receivers. Using OTP standards for emissions levels outside the emission bandwidth, it is necessary for the PAVE PAWS harmonic levels to be about 100 dB below the fundamental. Despite the fact that the OTP standards exist, exerience with other phased array radars has shown that the harmonic levels can be fairly high. For analysis purposes, it was assumed that the ninth harmonic emission level might be 70 dB below the fundamental or at the OTP required level.

The interference power due to the PAVE PAWS transmitter peak emission at the receiver site was calculated using the following equation:

$$P_I = P_T + G_T + G_R - L_B \qquad (2)$$

where

P_I = interfering power, dBm

P_T = PAVE PAWS power output at the frequency of interest, dBm

G_T = PAVE PAWS antenna gain in the direction of the victim receiver in dBi

G_R = victim receiver antenna gain in the direction of the PAVE PAWS, dBi

L_B = propagation loss, using the free-space spreading equation, dB

The interference-to-noise ratio was then calculated as follows:

$$INR = P_I - N_R \qquad (3)$$

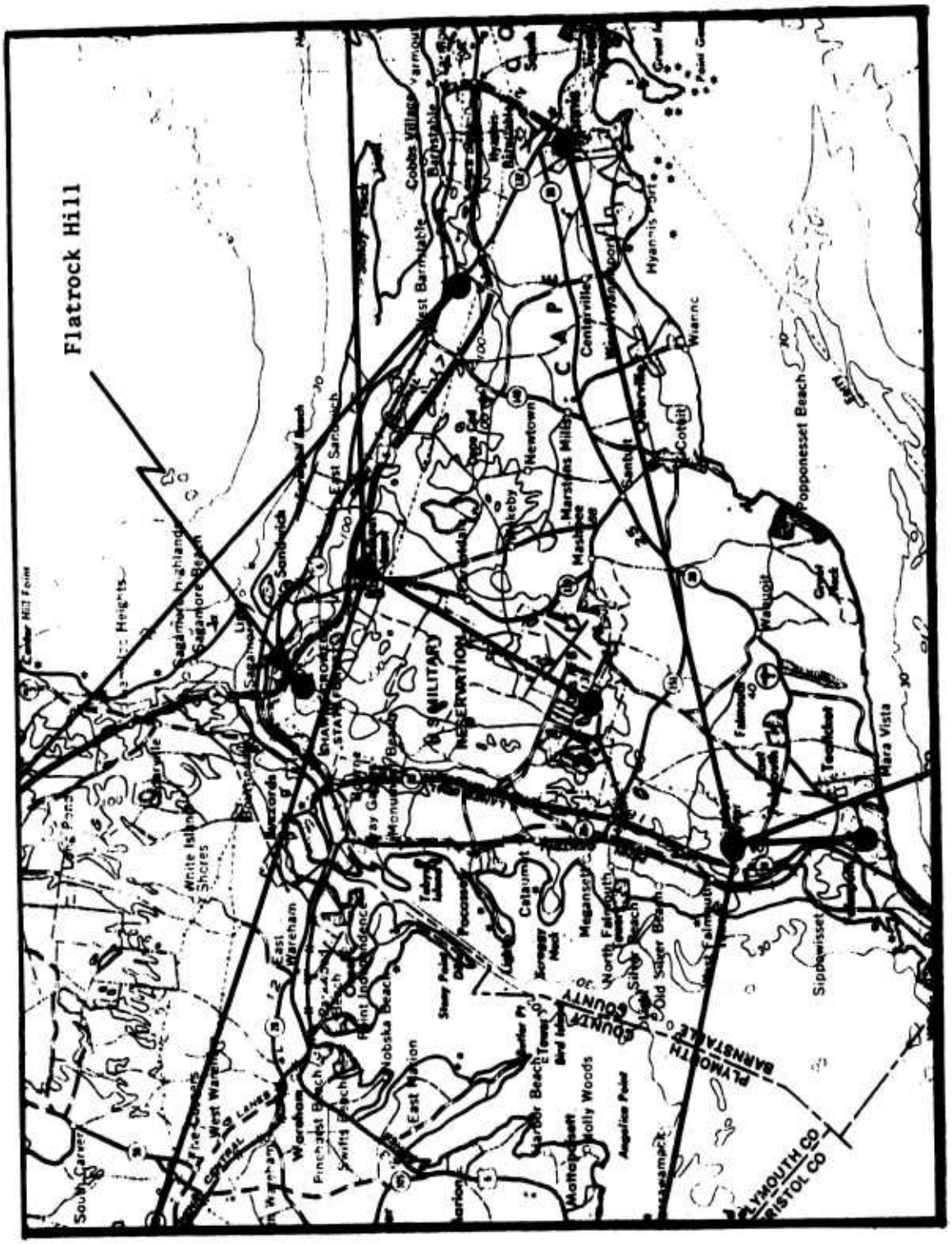

Figure 2. LOS microwave links near Otis AFB, Massachusetts.

where

INR = interference-to-noise ratio, dB

N_R = receiver noise threshold, dBm

For microwave systems, the desired signal level will normally be in excess of -40 dBm at the receiver input. However, the desired signal may fade to as low as -80 dBm. AT&T normally requires -10 dB INR to assure interference-free conditions even at the maximum fade. The results of these calculations are listed in TABLE 2. No interference will exist if the OTP standards are met.

UHF AIR-TO-GROUND AND GROUND-TO-AIR AM

The U.S. Military organizations use the 225-399.9 MHz frequency band for air-to-ground and ground-to-air voice communications. Many frequencies in that band are in use at Otis AFB. Previous work by ECAC[2] has shown that interference from pulse systems can be shown to exist when an articulation index (AI) falls below 0.7. This corresponds to an articulation score of at least 95%. The frequency band under discussion is 20 MHz or more away from the PAVE PAWS frequency band. According to Figure 6-29 of Reference 2,

[2] Hatch, W., Hinkle, R., and Mayler, R., "Analysis of Pulsed Interference to Amplitude Modulated Receivers", ESD-TR-70-207, ECAC, Annapolis, Md., Dec. 1970.

TABLE 2

PAVE PAWS INTERFERENCE TO LOS MICROWAVE

LOCATION	LATITUDE	LONGITUDE	LOS ANT. GAIN (dBi)	PAVE PAWS ANT. GAIN (dBi)	PROP. LOSS (dB)	I/N (dB) N = -90 dBm	
						$P_{harm} = -70$	$P_{harm} = -100$
Sandwich	41°43'48"N	70°29'28"W	+2	19.4	120	10.1	-19.9
Cataumet	41°39'10"N	70°33'18"W	-8	19.4	125	-4.9	-34.9
Brewster	41°44'07"N	70°03'02"W	+11	19.4	139	0.1	-29.9
Middleboro	41°49'30"N	70°51'08"W	+18	~0	133	-6.9	-36.9

a signal-to-peak interference ($S/\hat{I}$) ratio of -92 dB is required to maintain an AI of 0.7 at a frequency separation of 20 MHz. Assuming that the minimum desired signal at either the air or ground receiver is 10 dB above the receiver sensitivity level (or -80 dBm) and that the antenna gain of the victim receiver is +3 dB, the maximum allowable interference signal is +9 dBm.

Antenna gain values for scanning search phased array radars were determined from a previous ECAC report. Because the PAVE PAWS is a similar radar, the average antenna gain of 10 dBi in the direction of airborne receivers and 0 dBi in the direction of ground receivers were used. A propagation loss of 87 dB is required. Using the free-space loss equations for propagation losses, the required separation distances were calculated using the following:

$$20 \log D = L_R - 20 \log f - 36.6 \qquad (3)$$

where

D = Separation distance, miles

L_R = Required attenuation, dB

f = Operating frequency, MHz.

The separation distances necessary to ensure an AI of 0.7 are 2.4 miles for airborne equipment and 3/4 mile for ground equipment. These minimum separation distances are less than the distances to the normal operating locations of the AM equipments. Therefore, no interference to UHF air-to-ground and ground-to-air voice communications is anticipated.

UHF NARROWBAND FM

The 406.1 to 420 MHz frequency band is utilized for both fixed and land mobile FM voice communications by government agencies such as the the Departments of Commerce, Justice, and Treasury, the U.S. Air Force and the U.S. Coast Guard. The 450 to 470 MHz frequency band is allocated to land mobile FM voice communications by civilian users such as police departments, fire departments, taxicabs, citizen' band, remote pickup broadcast, and ambulance services. These frequency bands are adjacent to the UHF radar band, Measurements conducted on a typical UHF narrowband and FM receiver, the RT-524/VRC, are documented in ECAC-UM-75-005[3] and were conducted at a desired signal level of -101 dBm. From ECAC-UM-75-005, Figure A-49, an input signal-to-peak interference ($S/\hat{I}$) ratio of at least -83 dB is necessary to insure a minimum of 0.7 at a frequency separation of 650 KHz. The measurements were performed with a pulse rate of 40 pps and a pulse width of 1000 μs, however since the duty cycle is close to the PAVE PAWS radar, the threshold values should be similar. The threshold of -80 dB was used for the 10 msec pulses. This is an estimate as no measured or analytical data was available.

[3] Hernandez, A., "Empirical Study of Pulsed Interference to a Narrowband FM Voice Communications Receiver," ECAC-UM-75-005, June 1975.

SEPARATION DISTANCE

CRITERIA FOR NARROW BAND FM

Transmitter Ant. Gain (dBi)	S/I (dB) Threshold .7 AI at Δf= .65 MHz	Desired Signal Level (dBm)	Receiver Ant. Gain (dBi)	Prop. Loss (dB) Needed	Distance (miles)
0 front	-80*	-101	3	114	14.2
-10 back	-80*	-101	3	104	4.5

*estimate, no analytical or measured data available

For FM receivers not located on Otis AFB, the ECAC data files indicated that a FM receiver located in Middleboro (22 miles distant) at 419.325 MHz (closest Δf=0.675 MHz) had the greatest potential of being interfered with. The receiver at Middleboro is 22 miles from, and in the backlobe of, the PAVE PAWS radar so no interference is expected.

The radar should not cause interference to the other FM receivers in the environment except for equipments operating within the minimum distance separation at a time when the radar is transmitting near the edge of the frequency band (420 or 450 MHz). This interference situation could occur in the FM equipment at Otis AFB, on frequency 413.45 MHz, through high power effects.

TACAN

Airborne Receivers

None of the harmonic frequencies of the UHF band fall within the TACAN frequency range. Therefore, the only interference could come from spurious responses. Spurious responses to a receiver are found using the following:

$$f_{sp} = \frac{pf_{lo} \pm IF}{q} \pm \Delta f_{bw} \quad (4)$$

where

f_{sp} = the frequency of the undesired signal which causes the response, MHz

f_{lo} = the frequency of the local oscillator, MHz

IF = the receiver intermediate frequency, MHz

Δf_{bw} = a difference frequency equal to ½ of the receiver passband, MHz

p,q = integers denoting the harmonics of the local oscillator and the undesired signal contributing to the mix.

The only spurious response is generated by p = 2, q = 5 to which the TACAN receiver has approximately 90 dB rejection as previously reported.[4] In previous measurements[5] of the Safeguard radar (UHF phased-array radar - similar to the PAVE PAWS), no interference to TACAN or SIF/SSR systems aboard aircraft occurred at distances of 2 miles. Therefore, no interference to airborne TACAN receivers is predicted.

Ground Beacon Receivers

It was assumed that ground receivers have 80 dB spurious response rejection similar to the airborne receivers since there is a low pass filter in these receivers (a URN-3A is typical). Therefore, it was determined that adequate separation exists between the PAVE PAWS transmitter and the

[4] Hinkle, R., and Porter, R.D., Analysis of SAFEGUARD Interference to the Tactical Air Navigation System (TACAN), ESD-TR-72-005, ECAC, Annapolis, MD., April 1972.

[5] Moran, W., Carter, W., and Covert, J.C., "Test Program on EMC of Air Force Airborne C&E Systems and Army Safeguard Radars", ECAC-PR-74-13, ECAC, Annapolis, MD, April, 1974.

ground receiver to prevent interference.

A value of 5% reply countdown (loss of replies) was established as a criteria for the case of CW interference when an $S/\hat{I}$ of 10 dB is maintained. When this criteria is used with an average antenna gain of 0 dBi for the PAVE PAWS antenna and a spurious response rejection of 80 dB, a desired signal level of -75 dBm requires a distance separation of 0.5 miles for a transmitter with 88.7 dBm output. No interference to ground beacon receivers is anticipated.

HOME ENTERTAINMENT ELECTRONIC EQUIPMENT

The Flatrock Hill site is approximately one mile from the town of Sagamore, Mass. There are many homes that contain home entertainment electronic equipment which could receiver interference from the PAVE PAWS transmitter. No interference is anticipated to AM or FM radio receivers, Hi-Fi equipment nor any other electronics equipment other than TV home entertainment receivers. In a previous report, the effect of the UHF SAFEGUARD radar on TV receivers was analyzed and the following criteria were derived:

1. There would be no detectable interference at 95% of the TV receivers at one mile on channels 2 through 83 due to receiver saturation.

2. A spurious response caused by an interfering signal in the UHF band is generated when the TV receiver is tuned to channels 9, 10 or 11. 50% of the receivers would not detect this interference at a distance of 2.4 miles. This spurious response is generated for $p = 2$, $q = 1$.

3. Spurious response interference is also detectable on channels 60 through 83. 95% of the TV receivers would not detect this interference at a distance of 3 miles. 50% of the receivers would not detect this interference at one mile.

4. The second harmonic of the PAVE PAWS would fall in the pass-band of TV channels 75 to 83. Assuming that the second harmonic is 70 dB below the fundamental power output, this interference would not be detected beyond 5.8 miles.

TV broadcasts are available on channels 2, 4, 5, 7, 25, 38, 56, and 44 from Boston, Mass., on channel 6 from New Bedford, Mass., and on channels 10 and 36 from Providence, R.I. For the TV receivers in the vicinity of the PAVE PAWS radar, interference might be caused to those receivers tuned to channel 10 only. This interference could be avoided by not tuning the PAVE PAWS to 428 to 438 MHz or by adding filters to the input of all TV receivers within 5 miles.

PAVE PAWS INTERFERENCE TO ON-TUNED RADAR

The PAVE PAWS radar may share the frequency band with search radars. Interference to these radars will occur with no off-frequency rejection. The typical radar receiver in the UHF band will be assumed to have a sensitivity of -105 dBm to desired signals. However, non-synchronous pulsed interference will have a threshold 14 dB higher[6], or -91 dBm. The PAVE PAWS radar will emit 88.7 dBm of power and the back lobe antenna gain will be assumed to be -10 dBi. The receiver antenna will be assumed 0 dBi average gain. The propagation loss required is 169.6 dB and a distance separation of 26 miles is required for 50' antenna heights. The receiver threshold may be exceeded while the receiver antenna is pointed at the PAVE PAWS site, giving approximately 30 dB more interference power. However, this situation will only occur a small percentage of the time (.03%). In the UHF configuration, no radars operating between 420 to 450 MHz were located within the 26 mile minimum distance separation of the radar.

[6] Skolnick, Merril; Introduction to Radar Systems; McGraw-Hill, New York, NY, 1962.

POWER LINE INTERFERENCE TO PAVE PAWS

There are two high-voltage AC power lines approximately 3/4 mile from the Flatrock Hill site. According to an RADC report[7], power lines are sources of noise which might degrade a receiver in their vicinity. From the techniques provided by Reference 9, it was calculated that the 3/4 mile separation between the power lines and the PAVE PAWS site is adequate to reduce the noise level at UHF to a value low enough to preclude interference.

[7] Pakala, W.E., Taylor, E.R., Jr., and Harrold, R.T., High Voltage Power Line Siting Criteria, Vol. II, RADC-TR-66-606, Westinghouse Electric Corp., RADC GAFB, N.Y., March 1967.

ECAC-CR- 75-052 (Rev.3)

ATTACHMENT 3

PRELIMINARY ANALYSIS OF EMC IMPACT OF OTIS AFB PAVE PAWS ON THE SURROUNDING ENVIRONMENT

(REVISION 3 - GROWTH OPTION)

Frank S. Kravitz
Harry A. Siemen, Sr.

of
IIT Research Institute
Under Contract F-19628-73-C-0031 for the
DEPARTMENT OF DEFENSE
Electromagnetic Compatibility Analysis Center
Annapolis, Maryland 21402

CONSULTATIVE REPORT

Prepared for

AF System Command ESD
L. G. Hanscom AFB
Bedford, Mass. 01731

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This report was prepared by the IIT Research Institute, ECAC, North Severn, Annapolis, Md. 21402, under contract F-19628-73-C-0031 with the Electronic Systems Division of the Air Force Systems Command for the operation of the DoD Electromagnetic Compatibility Analysis Center.

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Director, DOD ECAC

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SECTION 1
INTRODUCTION

BACKGROUND

The U.S. Air Force is planning to deploy the PAVE PAWS phased-array warning system on the east and west coasts of the United States. The mission of the PAVE PAWS system is to detect and track sea-launched ballistic missile (SLBM) attacks on the continental United States and provide the Aerospace Defense Command with credible warning and attack assessment. The Electronic Systems Division (ESD) of the Air Force Systems Command (AFSC) is responsible for the development of the system.

Preliminary planning has been underway since late 1972. Site surveys have been included in that planning. One of the recommended sites is Otis AFB, Massachusetts. Three locations at Otis AFB were under consideration. Two have recently been eliminated. The remaining site under consideration is Flatrock Hill. This report is a preliminary electromagnetic compatibility (EMC) analysis to identify potential EMC problems at Flatrock Hill using the limited specification data presently available.

OBJECTIVE

The objective of this analysis was to identify potential interference to the electromagnetic environment from the PAVE PAWS Radar at the Flatrock Hill site on Otis AFB in Massachusetts.

The electromagnetic environment around the proposed site was determined from ECAC environmental data files. The technical characteristics for the victim receivers were assumed to be typical for each type of receiver in the environment. The technical characteristics of the PAVE PAWS radar were based on the data available in Reference 1.[1]

The effective interference power (P_i) was calculated from the following equation:

$$P_i = P_T + G_T + G_R - L_B - OFR \qquad (1)$$

where

P_T = interfering transmitter power, dBm

G_T = transmitting antenna gain, dBi

G_R = receiving antenna gain, dBi

L_3 = propagation path loss, dB

OFR = the amount of attenuation experienced by the interference signal as a result of receiver selectivity characteristics and the power spectral density characteristics of the interference signal, dB.

The effective interference power was compared to an interference threshold for each type of equipment to determine when interference would occur.

---

[1] "Phased Array Warning System PAVE PAWS Site Survey Report for East Coast Location", March 1975.

ANALYSIS

The parameters of the PAVE PAWS transmitter are given in TABLE 1.

TABLE 1

PAVE PAWS TRANSMITTER PARAMETERS

Peak Radiated Power Kilowatts (dBm)	1474/91.7
Pulse Width (Milliseconds)	10
PRF (Pulses per second)	27
Antenna Gain (dBi)	42.4
Antenna Sidelobe Attenuation (dB)	20

Using the data from TABLE 1, the Mason-Zimmerman spectrum for a PØ (pulsed emission) output was derived and is shown in Figure 1. A pulse rise and fall time of 1 microsecond was assumed. The antenna array will be constructed on two faces. The azimuth coverage shall be from 355°T eastward to 235°T (240° total coverage). The radar will search from 3° to 85° in elevation with a beam width of 2°. Therefore the ground will not be illuminated by the main beam.

The analysis was made to determine potential interference to receivers operating within 150 miles of the PAVE PAWS transmitter. Potential interference was investigated for in-band, adjacent-band, and harmonically related receivers. Where possible, the spurious response frequencies of the receiver were also investigated for potential interference. Those equipments specifically investigated were: Line-of-sight (LOS) microwave systems, TACAN systems, [illegible]-amplitude-modulated (AM) air-to-ground and ground-to-air systems, narrow-band [illegible] mobile systems, TV receivers, and radars.

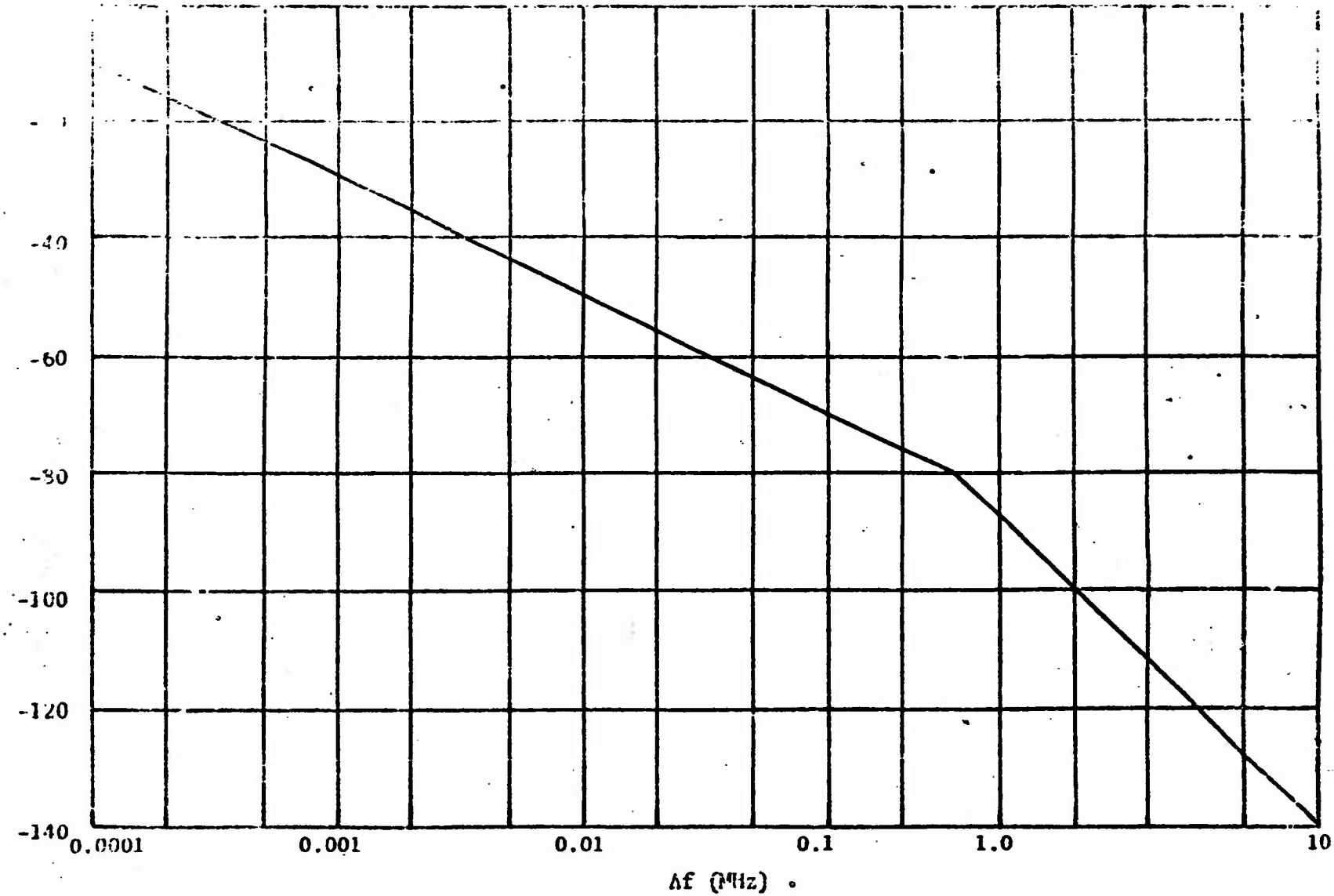

Figure 1. Simulated PAVE PAWS emission spectra.

2.1 MICROWAVE EQUIPMENTS

The LOS microwave links in the area around Otis AFB are shown in Figure 2. The links of interest located near the Flatrock Hill site operate in the 3710-4170 MHz frequency band. Interference to the microwave receivers could be produced by the ninth harmonic of the PAVE PAWS. These harmonics would fall within the passband of the microwave receivers. Using OTP standards for emissions levels outside the emission bandwidth, it is necessary for the PAVE PAWS harmonic levels to be about 100 dB below the fundamental. Despite the fact that the OTP standards exist, experience with other phased array radars has shown that the harmonic levels can be fairly high. For analysis purposes, it was assumed that the ninth harmonic emission level might be 70 dB below the fundamental or at the OTP required level.

The interference power due to the PAVE PAWS transmitter peak emission at the receiver site was calculated using the following equation:

$$P_I = P_T + G_T + G_R - L_B \qquad (2)$$

where

P_I = interfering power, dBm

P_T = PAVE PAWS power output at the frequency of interest, dBm

G_T = PAVE PAWS antenna gain in the direction of the victim receiver in dBi

G_R = victim receiver antenna gain in the direction of the PAVE PAWS, dBi

L_B = propagation loss, using the free-space spreading equation, dB

The interference-to-noise ratio was then calculated as follows:

$$INR = P_I - N_R \qquad (3)$$

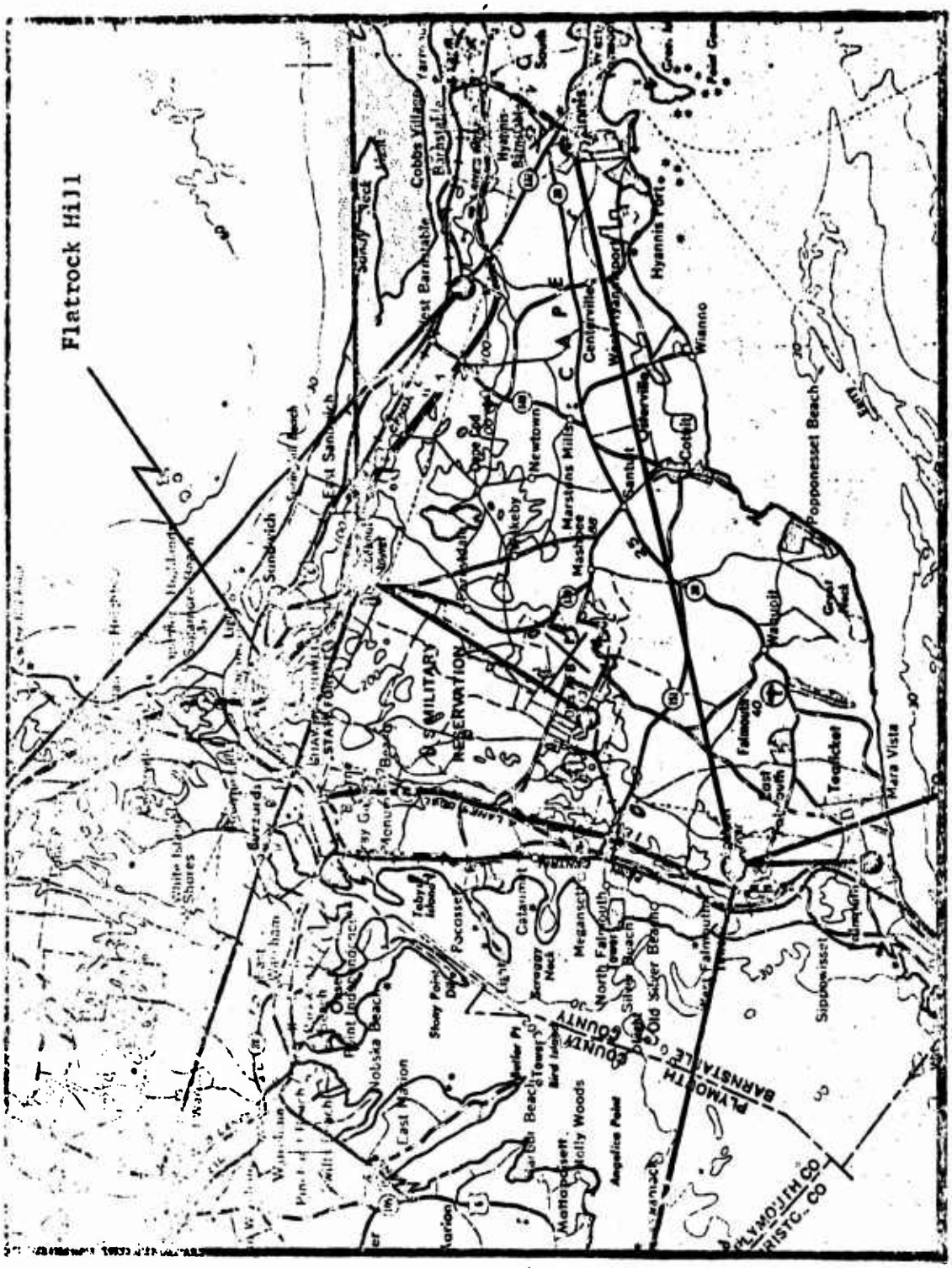

Figure 2. LOS microwave links near Otis AFB, Massachusetts.

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Where:

INR = interference-to-noise ratio, dB

N_R = receiver noise threshold, dBm

For microwave systems, the desired signal level will normally be in excess of -40 dBm at the receiver input. However, the desired signal may fade to as low as -80 dBm. AT&T normally requires -10 dB INR to assure interference-free conditions even at the maximum fade. The results of these calculations are listed in TABLE 2. No interference will exist if the OTP standards are met.

UHF AIR-TO-GROUND AND GROUND-TO-AIR AM

The U.S. Military organizations use the 225-399.9 MHz frequency band for air-to-ground and ground-to-air voice communications. Many frequencies in that band are in use at Otis AFB. Previous work by ECAC[2] has shown that interference from pulse systems can be shown to exist when an articulation index (AI) falls below 0.7. This corresponds to an articulation score of at least 95%. The frequency band under discussion is 20 MHz or more away from the PAVE PAWS frequency band. According to Figure 6-29 of Reference 2,

---

[2] Hinkle, R., Hinkle, R., and Mayler, R., "Analysis of Pulsed Interference to Amplitude Modulated Receivers", ESD-TR-70-207, ECAC, Annapolis, Md., Dec. 1970.

TABLE 2

PAVE PAWS INTERFERENCE TO LOS MICROWAVE

LOCATION	LATITUDE	LONGITUDE	LOS ANT. GAIN (dBi)	PAVE PAWS ANT. GAIN (dBi)	PROP. LOSS (dB)	I/N (dB) N = -90 dBm	
						$P_{harm} = -70$	$P_{harm} = -100$
Sandwich	41°43'48"N	70°29'28"W	+2	22.4	120	16.1	-13.9
Cataumet	41°39'10"N	70°33'18"W	-8	22.4	125	1.1	-28.9
Brewster	41°44'07"N	70°03'02"W	+11	22.4	139	6.1	-23.9
Middleboro	41°49'30"N	70°51'08"W	+18	~0	133	-6.9	-36.9

1984

a signal-to-peak interference ($S/\hat{I}$) ratio of -92 dB is required to maintain an AI of 0.7 at a frequency separation of 20 MHz. Assuming that the minimum desired signal at either the air or ground receiver is 10 dB above the receiver sensitivity level (or -80 dBm) and that the antenna gain of the victim receiver is +3 dB, the maximum allowable interference signal is +9 dBm.

Antenna gain values for scanning search phased array radars were determined from a previous ECAC report. Because the PAVE PAWS is a similar radar, the average antenna gain of 10 dBi in the direction of airborne receivers and 0 dBi in the direction of ground receivers were used. To prevent degradation propagation losses of 92.7 and 82.7 dB, respectively, are required. Using the free-space loss equations for propagation losses, the required separation distances were calculated using the following:

$$20 \log D = L_R - 20 \log f - 36.6 \qquad (3)$$

where

D = Separation distance, miles

L_R = Required attenuation, dB

f = Operating frequency, MHz.

The separation distances necessary to ensure an AI of 0.7 are 1.6 miles for airborne equipment and 0.5 mile for ground equipment. These minimum separation distances are less than the distances to the normal operating locations of the AM equipments. Therefore, no interference to UHF air-to-ground and ground-to-air voice communications is anticipated.

C.2 NARROWBAND FM

The 406.1 to 420 MHz frequency band is utilized for both fixed and land mobile FM voice communications by government agencies such as the the Departments of Commerce, Justice, and Treasury, the U.S. Air Force and the U.S. Coast Guard. The. 450 to 470 MHz frequency band is allocated to land mobile FM voice communications by civilian users such as police departments, fire departments, taxicabs, citizen' band, remote pickup broadcast, and ambulance services. These frequency bands are adjacent to the UHF radar band, Measurements conducted on a typical UHF narrowband and FM receiver, the RT-524/VRC, are documented in ECAC-UM-75-005[3] and were conducted at a desired signal level of -101 dBm. From ECAC-UM-75-005, Figure A-49, an input signal-to-peak interference ($S/\hat{I}$) ratio of at least -83 dB is necessary to insure a minimum of 0.7 at a frequency separation of 650 KHz. The measurements were performed with a pulse rate of 40 pps and a pulse width of 1000 μs, however since the duty cycle is close to the PAVE PAWS radar, the threshold values should be similar. The threshold of -80 dB was used for the 10 msec pulses. This is an estimate as no measured or analytical data was available.

[illegible] A., "Empirical Study of Pulsed Interference to a Narrowband [illegible] Communications Receiver," ECAC-UM-75-005, June 1975.

SEPARATION DISTANCE

CRITERIA FOR NARROW BAND FM

Transmitter Ant. Gain (dBi)	$\hat{S/I}$ (dB) Threshold .7 AI at Δf= .65 MHz	Desired Signal Level (dBm)	Receiver Ant. Gain (dBi)	Prop. Loss (dB) Needed	Distance (miles)
0 front	-80*	-101	3	117	20.1
-10 back	-80*	-101	3	107	6.4

*estimate, no analytical or measured data available

For FM receivers not located on Otis AFB, the ECAC data files indicated that a FM receiver located in Middleboro (22 miles distant) at 419.325 MHz (closest Δf=0.675 MHz) had the greatest potential of being interfered with. The receiver at Middleboro is 22 miles from, and in the backlobe of, the PAVE PAWS radar so no interference is expected.

The radar should not cause interference to the other FM receivers in the environment except for equipments operating within the minimum distance separation at a time when the radar is transmitting near the edge of the frequency band (420 or 450 MHz). This interference situation could occur in the FM equipment at Otis AFB, on frequency 413.45 MHz, through high power effects.

TACAN

Airborne Receivers

None of the harmonic frequencies of the UHF band fall within the TACAN frequency range. Therefore, the only interference could come from spurious responses. Spurious responses to a receiver are found using the following:

$$f_{sp} = \frac{pf_{lo} \pm IF}{q} \pm \Delta f_{bw} \qquad (4)$$

where

f_{sp} = the frequency of the undesired signal which causes the response, MHz

f_{lo} = the frequency of the local oscillator, MHz

IF = the receiver intermediate frequency, MHz

Δf_{bw} = a difference frequency equal to ½ of the receiver passband, MHz

p,q = integers denoting the harmonics of the local oscillator and the undesired signal contributing to the mix.

The only spurious response is generated by p = 2, q = 5 to which the TACAN receiver has approximately 90 dB rejection as previously reported.[4] In previous measurements[5] of the Safeguard radar (UHF phased-array radar - similar to the PAVE PAWS), no interference to TACAN or SIF/SSR systems aboard aircraft occurred at distances of 2 miles. Therefore, no interference to airborne TACAN receivers is predicted.

Ground Beacon Receivers

It was assumed that ground receivers have 80 dB spurious response rejection similar to the airborne receivers since there is a low pass filter in these receivers (a URN-3A is typical). Therefore, it was determined that adequate separation exists between the PAVE PAWS transmitter and the

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4 [illegible], R., and Porter, R.D., Analysis of SAFEGUARD Interference to the Tactical Air Navigation System (TACAN), ESD-TR-72-005, ECAC, Annapolis, MD., April 1972.

5 [illegible], R., Carter, W., and Covert, J.C., "Test Program on EMC of Air Force Air Borne CNE Systems and Army Safeguard Radars", ECAC-PR-74-13, ECAC, [illegible], MD, April, 1974.

ground receiver to prevent interference.

A value of 5% reply countdown (loss of replies) was established as a criteria for the case of CW interference when an $S/\hat{I}$ of 10 dB is maintained. When this criteria is used with an average antenna gain of 0 dBi for the PAVE PAWS antenna and a spurious response rejection of 80 dB, a desired signal level of -75 dBm requires a distance separation of 2.25 miles for a transmitter with 91.7 dBm output. No interference to ground beacon receivers is anticipated.

HOME ENTERTAINMENT ELECTRONIC EQUIPMENT

The Flatrock Hill site is approximately one mile from the town Sagamore, Mass. There are many homes that contain home entertainment electronic equipment which could receive interference from the PAVE PAWS transmitter. No interference is anticipated to AM or FM radio receivers, Hi-Fi equipment nor any other electronics equipment other than TV home entertainment receivers. In a previous report, the effect of the UHF SAFEGUARD radar on TV receivers was analyzed. The following criteria were derived for the PAVE PAWS from that report:

1. There would be no detectable interference at 95% of the TV receivers at 1.5 mileson channels 2 through 83 due to receiver saturation.

2. A spurious response caused by an interfering signal in the UHF band is generated when the TV receiver is tuned to channels 9, 10 or 11. 50% of the receivers would not detect this interference at a distance of 4.8 miles. This spurious response is generated for $p = 2$, $q = 1$.

3. Spurious response interference is also detectable on channels 60 through 83. 95% of the TV receivers would not detect this interference at a distance of 6 miles. 50% of the receivers would not detect this interference at two miles.

4. The second harmonic of the PAVE PAWS would fall in the pass-band of TV channels 75 to 83. Assuming that the second harmonic is 70 dB below the fundamental power output, this interference would not be detected beyond 11.6 miles.

TV broadcasts are available on channels 2, 4, 5, 7, 27, 38, 56, and 44 from Boston, Mass., on channel 6 from New Bedford, Mass., and on channels 10 and 36 from Providence, R.I. For the TV receivers in the vicinity of the PAVE PAWS radar, interference might be caused to those receivers tuned to channel 10 only. This interference could be avoided by not tuning the PAVE PAWS to 428 to 438 MHz or by adding filters to the input of all TV receivers within 10 miles.

PAVE PAWS INTERFERENCE TO ON-TUNED RADAR

The PAVE PAWS radar may share the frequency band with search radars. Interference to these radars will occur with no off-frequency rejection. The typical radar receiver in the UHF band will be assumed to have a sensitivity of -105 dBm to desired signals. However, non-synchronous pulsed interference will have a threshold 14 dB higher[6], or -91 dBm. The PAVE PAWS radar will emit 91.7 dBm of power and the back lobe antenna gain will be assumed to be -10 dBi. The receiver antenna will be assumed 0 dBi average gain. The propagation loss required is 173 dB and a distance separation of 50 miles is required for 50' antenna heights. The receiver threshold may be exceeded while the receiver antenna is pointed at the PAVE PAWS site, giving approximately 30 dB more interference power. However, this situation will only occur a small percentage of the time (.03%). In the UHF configuration, no radars operating between 420 to 450 MHz were located within the 50 mile minimum distance separation of the radar.

[6] Skolnik, Merril; Introduction to Radar Systems; McGraw-Hill, New York, N.Y., 1962.

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[illegible] INTERFERENCE TO PAVE PAWS

There are two high-voltage AC power lines approximately 3/4 mile from the Flatrock Hill site. According to an RADC report[7], power lines are sources of noise which might degrade a receiver in their vicinity. From the techniques provided by Reference 9, it was calculated that the 3/4 mile separation between the power lines and the PAVE PAWS site is adequate to reduce the noise level at UHF to a value low enough to preclude interference.

[illegible], Taylor, E.R., Jr., and Harrold, R.T., High Voltage Power Line Siting Criteria, Vol. II, RADC-TR-66-606, Westinghouse Electric Corp., RADC Griffiss, N.Y., March 1967.

ATTACHMENT 4
LOCAL AIR TRAFFIC CONSIDERATIONS FOR RADIATION HAZARDS

A. Local Air Traffic. Figure 1 shows the low altitude flight routes in the vicinity of Otis AFB, Mass. All low altitude air traffic in that vicinity either originates or terminates at nearby airports. Aircraft are expected to remain within one-half mile of these routes. The route which is closest to Otis AFB is V167 enroute to or from PEAK intersection. Aircraft using V167 fly at a minimum altitude of 2500 feet. V167, at its nearest approach is about 4.5 statute miles from the intersection of the Otis AFB runways.

B. The PAVE PAWS radar is expected to normally operate at a minimum boresight elevation angle of 3° and in a scanning search mode. The 3 dB beamwidth of the PAVE PAWS main beam is approximately 2 degrees. Consequently, the 3 dB point of the PAVE PAWS main beam will always be at an elevation angle of 2°, or greater. All aircraft at elevation angles from the site exceeding 2° can be illuminated by the PAVE PAWS main beam. Figure 2 shows the height to the low edge of the main beam as a function of distance from the transmitter. The slant range to aircraft at 2500 feet altitude on V167 is 11.5 statute miles from Flatrock Hill. From Figure 2 it can be seen that aircraft on V167 may be illuminated by the PAVE PAWS main beam.

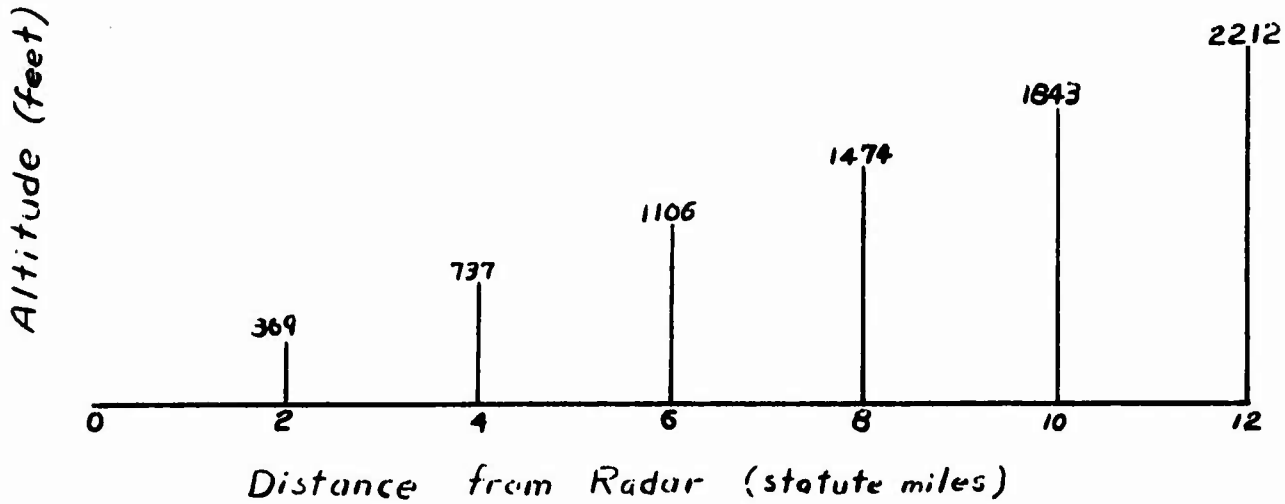

Figure 2 - Altitude of Beam at 2° Elevation

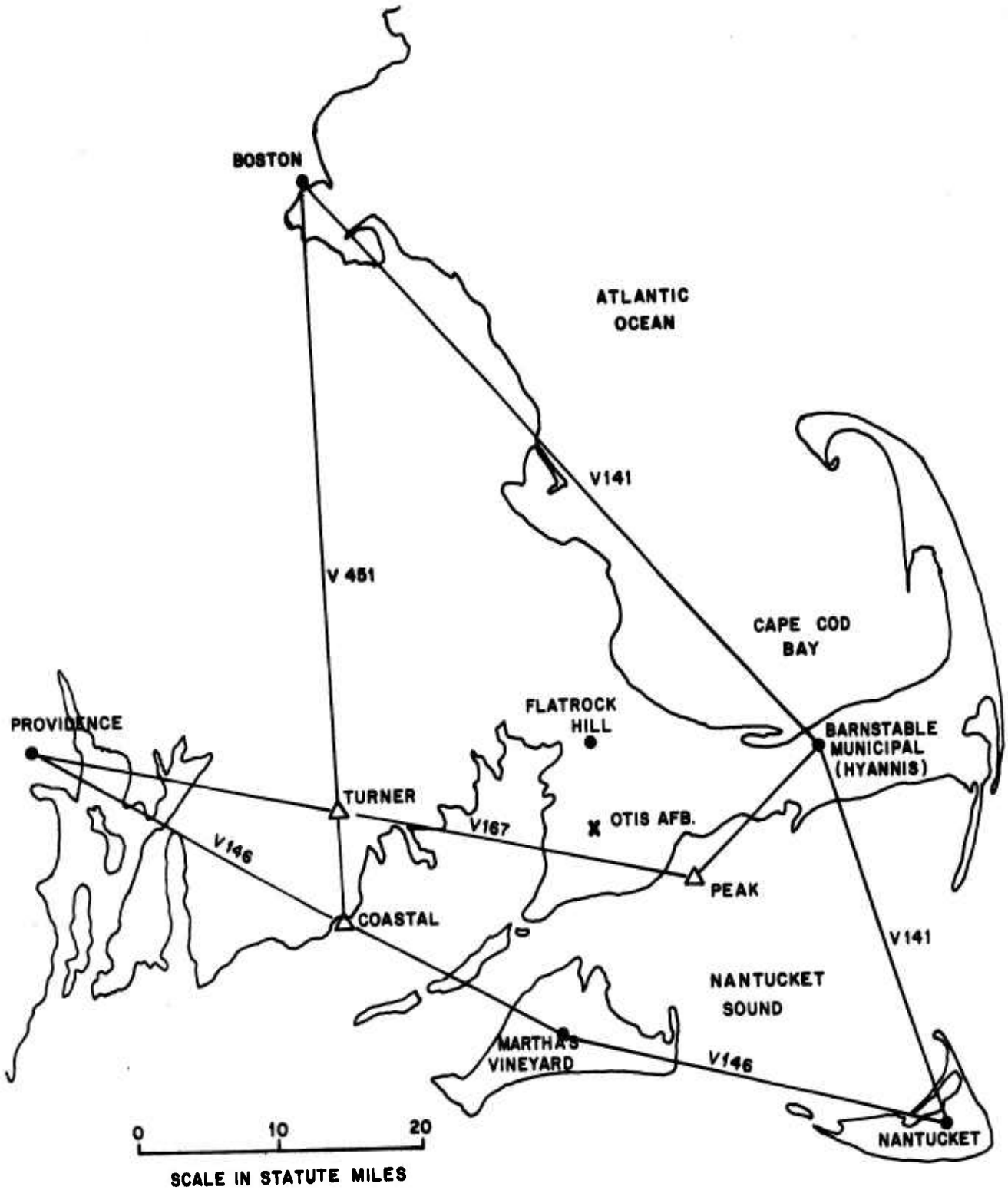
BOSTON
ATLANTIC
OCEAN
V141
V 451
CAPE COD
BAY
PROVIDENCE
FLATROCK
HILL
BARNSTABLE
MUNICIPAL
(HYANNIS)
TURNER
V167
OTIS AFB.
V146
PEAK
COASTAL
V141
NANTUCKET
SOUND
MARTHA'S
VINEYARD
V146
NANTUCKET
0
10
20
SCALE IN STATUTE MILES

Figure 1

C. The radiation hazards criterion for cardiac pacemakers is 200 volts/meter or 50 dbm/m^2 peak power density. The power density present at the nearest approach of V167 referenced to the pacemaker criterion of +50 dBm/m^2, peak power density is -18.2 db. Thus, the criterion will not be exceeded by the proposed system located at Flatrock Hill. Additionally, the metallic fuselage of commercial and military aircraft using V167 should easily provide 20 dB of shielding to the PAVE PAWS emissions. Consequently, the PAVE PAWS transmitter will not exceed the pacemaker criterion when applied to commercial and military aircraft using V167. Light aircraft with non-metallic fuselage covering using V167 will not be illuminated by a power density level exceeding the pacemaker criterion. The ordnance and personnel hazards criteria will not be exceeded by the PAVE PAWS system illuminating aircraft using V167.

D. Figure 3 shows the controlled aircraft approach to Hyannis airport. Traffic into and out of that airport should not approach close enough to the proposed PAVE PAWS sites to experience power density levels exceeding any radiation hazards criterion.

E. Figure 4 shows the controlled aircraft approaches to Otis AFB. As the aircraft approach for landing from 10 nautical miles out, they are at 1800 feet altitude. As they cross a point 5 nautical miles out, they are at 1400 feet altitude. Figure 5 shows the present VFR fixed-wing aircraft traffic patterns at Otis AFB. The traffic patterns for runways 14 and 32 may be reversed if the Otis AFB artillery restricted area is active. Aircraft using rectangular patterns will be at 1300 feet altitude. Aircraft using the 360° overhead traffic patterns will be at 1800 feet altitude overhead and could fly directly over the site.

F. Aircraft making controlled or VFR approaches to Otis AFB using the present patterns can be illuminated by the PAVE PAWS main beam. The distances beyond which biological and EED hazards criteria are not exceeded under main beam illumination conditions are given as follows:

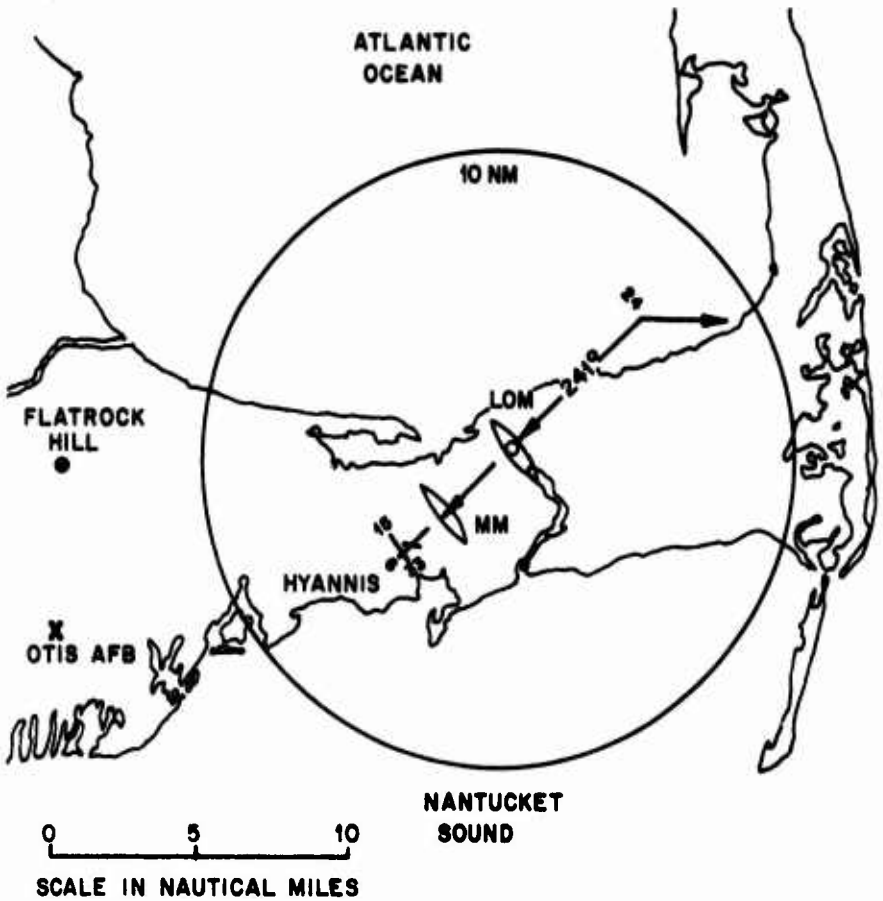
ATLANTIC
OCEAN
10 NM
FLATROCK
HILL
LOM
241°
MM
HYANNIS
OTIS AFB
NANTUCKET
SOUND
0
5
10
SCALE IN NAUTICAL MILES

Figure 3

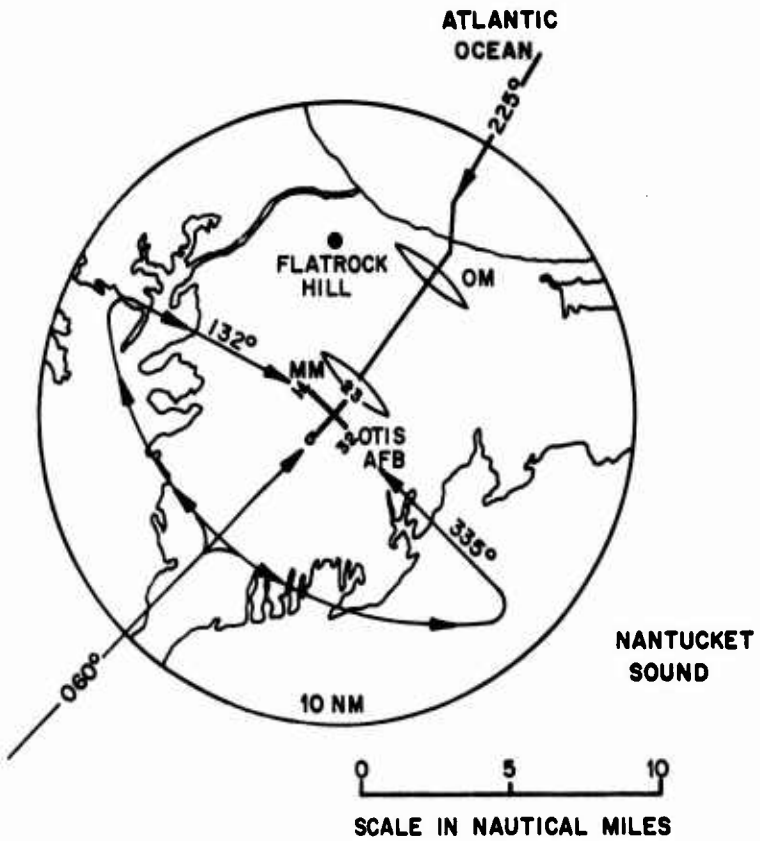
ATLANTIC
OCEAN
225°
FLATROCK
HILL
OM
132°
MM
OTIS
AFB
335°
NANTUCKET
SOUND
060°
10 NM
0
5
10
SCALE IN NAUTICAL MILES

Figure 4

FLATROCK HILL

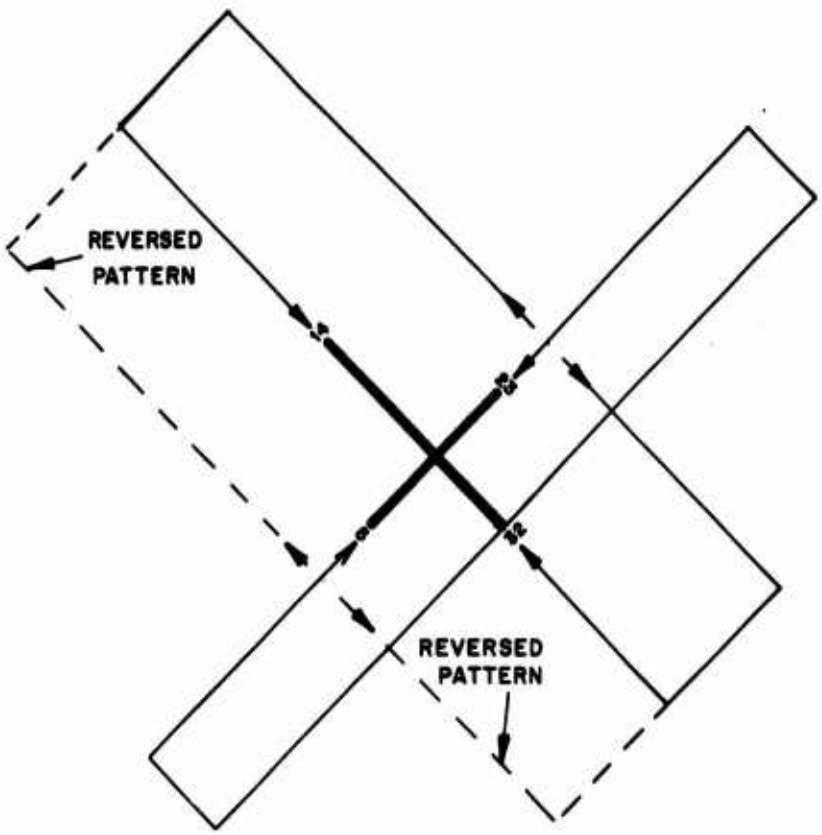

Figure 5

MAINBEAM HAZARD DISTANCES

Biological Effects	3790 feet
EED Hazards Wheels Up	3790 feet
Wheels Down	2.42 n.mi.

The criterion for hazards to personnel is based on average power density. The distances given above are calculated on the assumption of main beam illumination. Since the PAVE PAWS radar will normally operate in a scanning mode and because the aircraft are moving at fairly high rates of speed, constant illumination of an aircraft is an unrealistic condition. Because the aircraft is moving and because the radar is scanning, the true PAVE PAWS average power density present at an aircraft will be considerably lower than 10 mw/cm^2 (50 dBm/m^2) at the distance given in above table. Additionally, AFM 161-42 permits higher levels of power density for shorter periods of time in accordance with the following:

$$W = \frac{3600}{t}$$

where

t = exposure time in seconds

W = power density in mw/cm^2 (for values of t less than 360 sec)

With these mitigating circumstances in mind, biological hazards to personnel in aircraft using the present controlled or VFR approaches to Otis AFB can be ignored.

G. No allowances for higher radiation power densities for shorter periods of time are given for EEDs on flying aircraft. It will be necessary to restrict aircraft carrying EEDs from flying closer to the radar than 3790 ft for wheels up and 2.42 n.mi. for wheels down. Controlling the VFR landing patterns similarly to the control now exercised when the restricted area is active would suffice to eliminate that hazard. This consists of reversing traffic patterns for runways 14 and 32.

H. Interference to electronic equipment through a phenomenon called "high power effects" (HPE) can occur when the equipment is in the vicinity of a high power transmitter such as PAVE PAWS. The interference is temporary and no permanent damage is sustained. For aircraft, this type of interference may occur at power density levels as low as +40dBm/m^2. The distance at which this criterion would be exceeded is 1850 ft.

This distance was calculated assuming that the aircraft and equipment chassis will provide 25dB of shielding to the PAVE PAWS emissions and assuming main beam illumination conditions. This distance is sufficiently small to allow normal operations with the simple restrictions placed on aircraft in the VFR landing patterns.

APPENDIX VI

A - Methodology and Data Tables
AN/FSS-7 and LRR Sites

B - Methodology for Data at Otis AFB

Appendix VI

Environmental Assessment

Title Page

1. (U) Name of Action: Phased Array Warning System (PAVE PAWS); Replacement of six AN/FSS-7 SLBM Detection Radars.

2. (U) Major Command: Aerospace Defense Command.

3. (U) Date Prepared: 15 Sep 1975.

4. (U) Prepared By:

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5. (U) Approved By:

Owen A. Moore
OWEN A. MOORE, P.E. GS-13
Command Environmental Coordinator

Date: 17 Sep. 75

Morris B. Rubenstein
MORRIS B. RUBENSTEIN, Col, USAF
Chairman, ADCOM Environmental Protection Committee

Date: 17 SEP 1975

6. (U) Prepared in accordance with AFR 19-2 in compliance with the National Environmental Policy Act of 1969.

Appendix VI

TABLE OF CONTENTS

Summary

(U) This assessment considers the environmental effects of replacing the current system of six AN/FSS-7 SLBM detection radars with two PAVE PAWS phased array radars, one on each coast. Overall, the ecological impacts are minimal; however, the social and economic effects on a few local communities are significant with particularly detrimental effects predicted in Tillamook, OR. Closure action is justified on the basis of the favorable overall environmental impact and the military operational and economic advantages. However, special ADCOM assistance is recommended to assure economic stability in Tillamook, OR.

1. Project Description:

(U) This assessment considers the environmental and socio-economic effects of replacing the current system of six AN/FSS-7 SLBM detection radars with two PAVE PAWS phased array radars, one on each coast. The AN/FSS-7 radars are located at MacDill AFB, FL; Mt Hebo AFS, OR; Mill Valley AFS, CA; Mt Laguna AFS, CA; Ft Fisher AFS, NC; and Charleston AFS, ME. The PAVE PAWS radars will be located at Otis AFB, MA and Beale AFB, CA. The AN/FSS-7 radars will be phased out when the PAVE PAWS radar on their respective coast becomes operational. The AN/FSS-7 radars are all colocated with Long Range Radars (LRR). The LRRs will either be phased out or turned over to the Federal Aviation Agency (FAA) for use in the Joint Surveillance System (JSS). The socio-economic effects of the phase out/turnover of the LRRs will also be addressed.

2. The Probable Environmental Impact of the Proposed Action:

(U) Six existing ADCOM units are affected by this proposal and each will be reduced in strength by the number of personnel assigned to the headquarters and detachments of the 14MWS. These reductions will also cause a corresponding reduction in support personnel. The total reduction in Air Force funded ADCOM payroll at each of the 6 affected locations will cause a corresponding reduction in the local community economy. Ecological and environmental impacts are assessed as minimal and possibly beneficial since many of these people are presently assigned at remote and difficult-to-support locations where much fuel is consumed in winter and in transportation and where water and sewage treatment are difficult to provide.

(U) In contrast, the socio-economic effects on a few local communities will be significant, especially when the impact of this action is considered in connection with other actions (JSS) which will result in complete elimination of the Long Range Radar function at Charleston, ME; Ft Fisher, NC; Mill Valley, CA and Mt Hebo, OR. The combined effects of both actions in the smallest community (Mt Hebo AFS, Tillamook, OR) will result in changes in the socio-economic characteristics of this community, estimated as follows: population loss 29.6%, employment loss 24.2% and wage income loss 20.9%.

a. (U) Ecological Impacts. Reductions at the six affected radar squadrons will have a generally beneficial effect upon the following factors: air quality, water quality, noise, solid waste disposal, electromagnetic radiation, energy supply, natural resources, vegetation, wild life, marine life and food resources. The magnitude of the beneficial effects is difficult to estimate and unnecessary, since no adverse impact is forecast.

b. (U) Land Use and Land Management. The facilities to be vacated are on U.S. government installations constructed in the early 1950's to provide radar detection and mission support facilities including living space for as many as 300 people at each location. Although the structures are fully depreciated in an economic sense, their well-maintained condition indicates that suitable alternative uses for the facilities should be obtained in order to realize a maximum return on the invested cost. This will be difficult in remote locations. However, in growing communities reasonable alternatives exist. In the most difficult cases, Mt Hebo OR and Charleston ME, it is expected no alternative uses may be found for some time. At MacDill FL and Mt Laguna CA the operational LRR facilities will continue to be used by the FAA. Past experience indicates the cost of maintaining a vacant radar site in a pickled caretaker status, while alternative uses are found, at $200,000 per year for an average of 3 years. The total "start-up" costs of the PAVE PAWS and JSS programs should therefore be increased by the maximum total caretaker operations and maintenance cost of 4 x 3 x $200,000 or $2,400,000 for the closures involved in this action.

c. (U) Economic and Social Effects. This is the category in which the greatest adverse environmental impact occurs. Personnel reductions in the headquarters and detachments of the 14MWS will initiate corresponding reductions in support personnel and in community employment, population and income. Table 1 provides estimates of percent changes in community economic and social characteristics under two different conditions; 1A shows the impact of reductions due to PAVE PAWS actions only; 1B shows the impact including complete closure at four sites due to combined PAVE PAWS and JSS dislocations.

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Table 1

Predicted Change in Community Economic and Social Characteristics - Percent (1)

A. PAWS Actions Only (without JSS)

Site	Population	Employment	Wages
Charleston, ME	1.07	0.85	1.29
Ft Fisher, NC	0.87	0.64	0.38
MacDill, FL	0.15	0.12	0.11
Mill Valley, CA	0.60	0.42	0.17
Mt Laguna, CA	0.61	0.47	0.21
Mt Hebo, OR	10.6	8.6	4.5

B. Including JSS Actions with PAWS Actions

Site	Population	Employment	Wages
Charleston, ME	2.93	2.32	2.29
Ft Fisher, NC	2.31	1.70	1.74
MacDill, FL	0.20	0.15	0.17
Mill Valley, CA	1.56	1.09	0.71
Mt Laguna, CA	1.13	1.02	0.75
Mt Hebo, OR	29.6	24.2	20.9

(1) All percentages are negative. Estimates are for the time of anticipated reduction or closure.

The most adversely affected community is the town of Tillamook, Oregon where 10.6% of the population will be affected, 8.6% of total employment (military, civilian and community) will be lost and 4.5% loss in income from wages and salaries will occur due solely to the "ripple" effect of moving personnel of Det 2, 14MWS to other assignments if PAVE PAWS is implemented. These estimates may be reduced somewhat by offsetting actions and circumstances not in accordance with the basic assumptions made in the calculations as explained in Appendix VI-A. However, the severity of the local impact on Tillamook should be recognized as being approximately four to ten times as great as on the next most severly affected community. At Charleston, ME the local effects are estimated at approximately 1% of population, employment and wages, as shown in Table 1.

When the impact of the combined actions involved in PAVE PAWS and closure of the LRR's in the JSS program is estimated the results are as shown in Table 1B. Noticably adverse effects (greater than 1%) occur at Mt Hebo (Tillamook approximately 25%), Charleston (Bangor and Dover-Foxcroft approximately 2 1/2%) and Ft Fisher (Wilmington approximately 2%). At Mt Hebo the adverse impact will be so substantial that special actions and assistance are recommended to preclude disintegration of the small community involved. It is specifically recommended that a constructive and effective use for this facility be obtained before any public announcement of closure is made.

3. (U) Probable Adverse Environmental Effect Which Cannot Be Avoided Should the Proposal Be Implemented. There are no significantly adverse ecological effects from the closures evaluated in this discussion. The unavoidable social and economic effects will be most severe in the small town of Tillamook, Oregon. Noticably adverse impacts will occur in the vicinity of Charleston, Maine and Wilmington, North Carolina. Negligible impacts will arise in the communities near Mt Laguna (El Cajon, California), Mill Valley (Mill Valley and San Rafael, California) and MacDill (Tampa, Florida). These impacts are summarized in Table 1, described previously and enumerated in Appendix VI-A.

4. (U) Alternatives to the Proposed Action. These factors are discussed in the main body of the report.

5. (U) Relationship Between Local Short-Term Use of Man's Environment and the Maintenance and Enhancement of Long-Term Productivity. This action is justified in terms of military operational and economic validity. To the extent that it reduces presently adverse ecological effects in remote and rural areas of the countryside the effects may be considered beneficial. To the extent that it concentrates resources and personnel on existing well-developed and support military installations the effects are also considered to be an enhancement of long-term productivity and a fulfillment of the military operational objectives involved.

6. (U) Any Irreversible and Irretrievable Commitments of Resources which would be Involved in the Proposed Action Should It be Implemented. Resource commitments for the deactivation and closure actions are small in comparison to the total project. Personnel transfer costs incurred as a result of PAVE

PAWS involve 57 officers at $2,374 each and 191 enlisted at $1,027 each total $331,475, and are not recoverable.

In event of both actions being implemented resulting in closure of four sites and transfer of two to the FAA, an additional caretaker operation and maintenance cost of $2,400,000 will be irreversibly lost to the Air Force and should be allocated to each of the two programs in proportion to the facility space they present occupy.

Resource committments for the construction phases of PAVE PAWS are discussed in the main body of the report.

7. (U) Considerations that Offset the Adverse Environmental Effects. The adverse effects identified in this assessment are social and economic, impacting predominantly upon three small communities in the vicinity of the radar squadrons at Mt Hebo OR, Charleston ME and Ft Fisher, NC. In the case of Mt Hebo and the community of Tillamook, Oregon it is recommended that ADCOM make a specific committment to secure and commit an alternative use for the site prior to any public announcement of closure. The possibilities are several and could include such diverse considerations as an astronomical observatory, communications ground station, state detention facility, community college, etc. In the cases of Charleston and Ft Fisher the surrounding communities are larger and the proposed actions sufficiently long range that gradual phasing of the reductions may provide sufficient time for community economic and social adjustments. The major offsetting considerations are the military operational and economic benefits to be gained from consolidation of the mission and functions of the FSS-7 radars at only two sites, one on the east coast and one on the west coast. These are evaluated in the main body of the report.

8. (U) Details of Unresolved Controversies or Issues. The most highly controversial issue foreseen as a result of this proposal is the generally adverse economic and social impact of closure on the small community of Tillamook, Oregon and, to a lesser extent, on the communities near Charleston AFS, Maine and Ft Fisher AFS, NC. The following actions shall be taken:

a. Extend the time for relocation of Det 2, 14MWS past the expected implementation date pending committment of

alternative uses for the site. (Action: ADCOM/XP)

b. Establish a concerted program to contact potential alternative federal and state agencies establish a new use for the site and secure a committment prior to closure announcement. (Action: ADCOM/DEPE)

9. (U) References.

a. AF Regulation 19-2, Environmental Assessments and Statements, 22 November 1974.

b. AF Regulation 173-10, USAF Cost and Planning Factors (FOUO), 16 May 1975, Tables 20, 25 and 49, as modified by USAF/ACMCA letter 6 Feb 1975.

c. Executive Order 11724 Installation Survey Brochures for the following installations and dates:

(1) Charleston AFS, ME (13 Feb 1974),
(2) Ft Fisher AFS, NC (30 Jan 1975),
(3) Mt Hebo AFS, FL (7 Aug 1973),
(4) Mt Laguna AFS, OR (11 Feb 1974), and
(5) Mill Valley AFS, CA (9 Apr 1973).

d. U.S. Department of Commerce, County and City Data Book, U.S. Government Printing Office (1972).

e. ADCOM/DOTE Report of Environmental Assessment for Consolidation of Florida Air Defense Control and Weapons Controller Training at Tyndall AFB, FL, 8 Aug 1975.

f. SAC/DEPA private communication 10 Sep 1975 regarding: AICUZ Report on Davis-Monthan AFB, AZ dated August 1975.

g. CSAF/RPEV private communication 10 Sep 1975 regarding: Batelle Columbus Laboratory Report, Assessment of Potential Socio-Economic Impact upon the Utica-Rome SMSA Resulting from Realignment of Rome Air Development Center, Griffiss AFB, NY, dated 15 Apr 1975.

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Appendix VI-A

Methodology and Data Tables

1. (U) Wage and Salary Effects

a. The personnel salary figures used for computation of both personnel dollar savings to the Air Force and economic impacts on the areas in question were drawn from Table 20, AF Regulation 173-10 for fiscal year 1976, as amended, 6 Feb 1975. Inflation factors to convert base year data to proposed year data were derived from Table 49.

b. The economic and social impacts evaluated in this study are based on the partial changes of operating mission at small radar site installations on the east and west coasts. These changes in operating personnel will have an impact on support personnel required at the site. Since the sites are small, the impact of this change will be greater than the relatively small changes at a main support base. To simplify the estimates, for this study it has been assumed that each reduction in an operating position at a small site causes an equal reduction in support positions and multiplication factor of 2.0 was used to estimate total Air Force position and salary reductions. In the cases of decreases or increases at existing major operating locations the change of support personnel requirements was estimated at 18.6% of the added manning and salary cost.

c. The economic impact of the local gain or loss to the community of spending military pay is computed at 50% of the composite figures drawn from AFR 173-10. The rationale behind this percentage is that 25% of the composite figure represents income tax withholding, social security withholding, benefits, etc and that this 25% is not available for local expenditure. An additional 25% is not expended in the local economy and represents savings, investments, insurance premiums, payments to national corporations, etc. The remaining 50% represents income disposable in the local economy. For civilian pay the gain or loss was estimated at 90% of salaries.

d. The estimate that change of one military position triggers a change of .66 of one job and that change of one

civilian position triggers change of 1.58 job in the service sector of the civilian economy is drawn from previous environmental assessments and impact statements prepared by Aerospace Defense Command and Strategic Air Command.

2. (U) Population Effects

Population data for employed personnel including dependents were calculated on the basis of 2.5 dependents per wage earner, civilian and military.

3. (U) Community Population and Employment in the Future

Population data for the 1970 census were expanded to the anticipated date of actions on the basis of locally reported projections of 1980 population. In one case, Tampa, FL, only 1970 and 1975 data on employment were available and the projection to 1980 was made on this basis.

4. (U) Inflation Costs

In order to compare wage and salary costs in the same time frame, both community wage and salary income (1970 data) as well as federal Air Force wage and salary income (1975 data) were expanded to the same implementation time frame using the inflation factors derived from AFR 173-10.

5. (U) List of Tables in Appendix VI-A

Table 2 - Salary and Wage Income for MWS Headquarters

Table 3 - Salary and Wage Income for Typical MWS Detachment

Table 4 - Calculation of Employment and Spending Impacts for MWS Hdqtrs Only

Table 5 - Calculation of Employment and Spending Impacts for Typical MWS Detachment

Table 6 - Summary of Total Impact for Each MWS Site

Table 7 - Community Data Summary (1970 Census)

Table 8 - Community Economic and Social Data Base for Time of Implementation

TABLE 2 (U)

Salary and Wage Income for MWS Headquarters (for MacDill AFB, FL)

Grade/Rank	Number of Employees	Annual Cost(1)	Total Income
O-6	1	$32,088	$ 32,088
O-5	2	28,434	56,868
O-4	4	23,750	95,000
O-3	4	20,256	81,024
O-2	6	15,349	92,094
E-8	2	15,659	31,318
E-7	11	13,667	150,337
E-6	15	11,887	178,305
E-5	28	10,284	287,952
E-4	5	8,492	42,460
E-3	7	7,102	49,714
Civ	8	14,427	115,416
Total Military	68		$1,097,160
Total Civilian	8		115,416
			$1,212,576

(1) Per AFR 173-10

TABLE 3 (U)

Salary and Wage Income for Typical MWS Detachment
(for Charleston, Ft Fisher, Mill Valley, Mt Laguna, Mt Hebo)

Grade/Rank	Number of Employees	Annual Cost(1)	Total Income
O-4	1	$23,750	$ 23,750
O-3	3	20,256	60,768
O-2	4	15,309	61,236
E-8	1	15,659	15,659
E-7	2	13,667	27,334
E-6	7	11,887	83,209
E-5	17	10,284	174,828
E-4	1	8,492	8,042
E-3	8	7,102	56,816
Civ	2	14,427	28,854
Total Military	36		$511,642
Total Civlian	2		28,854
			$540,496

(1) Per AFR 173-10

TABLE 4 (U)

Calculation of Employment and Spending Impacts (MWS Hdqtrs, Only)

a. Employment at Support Base (MacDill):

1.186 x 76 = 90 (Military and Civilian)

b. Employment in local community

0.66 x military (80) = 52.8
1.58 x civilian (10) = 15.8

Total 69

c. Affected wages and salaries:

1.186	x $1,212,576	=	$1,438,115
.50	x $1,301,231 (m)	=	650,615
.90	x $ 136,883 (C)	=	129,843
	Total		$2,211,924

or $2.21 x 10^6 (1975) x 1.414

or $3.12 x 10^6 (1980)

d. Affected population at 3.5 members per family

3.5 (90 + 69) = 3.5 x 159 = 557

TABLE 5 (U)

Calculation of Employment and Spending Impacts for Typical MWS Detachment

a. Employment at Radar Squadron

2.0 x 38 = 76

b. Employment in local community

0.66 x 72 (military) = 47.52
1.58 x 4 (civilian) = 6.32

Total 54

c. Affected wages and salaries

2.0 x 540,496 = $1,080,992
.50 x $1,023,284 = 511,642
.90 x $ 57,708 = 51,937

Total $1,644,571

or $1.64 x 10^6 (1975) x 1.414

or 4.33 x 10^6 (1980)

d. Affected population at 3.5 members per family

3.5 x (76 + 54) = 3.5 x 130 = 455

TABLE 6 (U)

Summary of Total Impact for Each MWS Site

A. PAWS Actions Only (without JSS Actions)

Site	Population	Employment	Wages 1980 $x10^6
Charleston	455	130	1.02
Ft Fisher	455	130	1.03
MacDill	557	159	2.09
Mill Valley	455	130	1.27
Mt Laguna	455	130	1.11
Mt Hebo	455	130	1.06

B. Including JSS Actions with PAWS Actions

Site	Population	Employment	Wages 1980 $x10^6
Charleston	1246	356	4.72
Ft Fisher	1218	348	4.68
MacDill	714	204	3.28
Mill Valley	1190	340	5.21
Mt Laguna	980	280	4.01
Mt Hebo	1274	364	4.92

TABLE 7 (U)

Community Data Summary (1970 Census)

Communities	Population	Employment	Per Capita Income	Total Income Wages $x10^6$	Projected 1980 Population
Marin Cty, CA	206,038	80,620	4,794	987.7	259,000
Mill Valley	12,942			62.0	
Corte Madera	8,464			40.5	
San Rafael	38,977		4,914	191.5	
Community Total	60,383	24,877		294.0	76,082
San Diego Cty, CA: data not applied (N/A)					
El Cajon	52,273	19,260	3,325	173.8	74,750
Hillsborough Cty, FL	N/A	181,351	N/A	N/A	235,300 (1)
Tampa	277,753	103,742	2,779	771.9	361,079
Penobscott Cty, ME	125,393	45,362	2,458	308.2	N/A
Bangor	33,168	11,940	2,458	81.5	
Dover-Foxcroft	4,178	1,504	2,458	10.3	
Community Total	37,346	13,444		91.8	42,574
New Hanover Cty, NC	82,966	N/A	N/A	N/A	94,250
Wilmington	46,169	17,939	2,584	119.3	52,633
Tillamook Cty, OR	17,922	6,230	2,843	51.0	19,500
Tillamook	3,968	1,389	2,843	11.3	4,300

TABLE 8 (U)

Community Economic and Social Data Base for Time of Implementation

Site	Community Data		
	Population	Employment	Wage Income ($x10^6$)
Charleston, ME	42,574	15,326	206.5
Ft Fisher, NC	52,633	20,450	268.3
MacDill, FL	361,079	134,865	1979.2
Mill Valley, CA	76,082	31,345	730.6
Mt Laguna, CA	74,750	30,238	538.3
Mt Hebo, OR	4,300	1,505	23.6

APPENDIX VI-B

Methodology for Determining Employment and Income Data for PAVE PAWS at Otis AFB.

The socio-economic effects computed for the Blue Suit and Contractor Support alternatives were obtained in the following manner.

•Otis Employment - Manning was determined by the Aerospace Defense Command based on their experience at other radar installations. The Blue Suit option would employ 248 people consisting of 22 officers, 181 airment and 45 government service personnel. The contractor support option would employ 173 people consisting of 12 officers, 58 airmen, 13 government service and 90 contractor personnel. Base support personnel are included.

•Otis Wages and Salaries - These are annual wages paid to the above personnel and were computed using the following general rates based on AFM 173-10.

Officers	- $ 19,606
Airmen	- $ 8,986
Government Service	- $ 14,036
Contractor	- $ 15,000

•Otis Residents - The number of residents was computed as 3.5 times the number of military employees. All military are assumed to live on base.

This same factor has been used in Appendix VI-A.

Community Employment - The number of service related jobs expected to develop in the community as a result of the influx of PAVE PAWS personnel is computed as .66 times military plus 1.58 times civilian personnel. The same factors have been used in Appendix VI-A.

Community Wages & Salaries - This figure represents that portion of the PAVE PAWS military and civilian income that would find its way into the local community. The factors used were derived from Appendix VI-A, .5 times military income plus .9 times civilian income.

Community Residents - This is the sum of PAVE PAWS civilian employment and community employment again multiplied by 3.5 to include dependents. All PAVE PAWS civilian employees are assummed to live in the community.

APPENDIX VII

"USAF SCHOOL OF AEROSPACE MEDICINE"

CLARIFICATIONS

17 September 1975

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS OF AEROSPACE MEDICINE (AFSC)
BROOKS AIR FORCE BASE, TEXAS 78235

REPLY TO ATTN OF: RAP/Mr. Mitchell

SUBJECT: PAVE PAWS Environmental Assessment

TO: AMD/RDR

1. Reference ESD/OCLE letter to SAM/RAP, same subject, dated 5 Sep 1975.

2. Please forward the following comments to ESD/OCL for their use in rewriting the subject Environmental Assessment.

a. Radiofrequency Radiation Personnel Exposure Guidelines are contained in AFR 161-42, "Radiofrequency Radiation Hazards Control" (supersedes AFM 161-7). For exposed time of over 6 minutes, the 10 mW/cm^2 power density level should not be exceeded. For exposure times of less than 6 minutes, the product of the incident power density level and time should not exceed 3600 $mW\text{-}sec/cm^2$. These guidelines are consistent with Title 29 CFR 1910.97, OSHA nonionizing radiation health standard and American National Standard ANSI C95.1-1974, Safety Level of Electromagnetic Radiation with Respect to Personnel.

b. Three years ago, ~80% of the cardiac pacemakers in use had electromagnetic interference (EMI) thresholds of 10 volts per meter (V/m). Today, only ~20% have EMI thresholds of 10 V/m, and over 50% have thresholds greater than 200 V/m. By 1978 pacemakers should have EMI thresholds greater than 200 rms V/m. Pacemaker interference is judged nonhazardous unless the pacemaker misses 5 or more consecutive beats or falls below an average rate of 50 beats per minute (bpm). Thus, significant pacemaker interference should not occur unless the E-field level exceeds 200 V/m for a sufficient period of time to result in the pacemaker missing ~5 beats in 5 seconds, or 20 beats in a minute. Using these criteria, cardiac pacemaker users in aircraft would not be in danger.

c. The information provided in Appendix IV, page 9, Microwave Radiation, is not correct. The Air Force cannot regulate pacemaker quality, and we do not recommend any changes in "microwave operation" to accommodate pacemakers. Also, other paragraphs in Appendix IV, pages 9 and 10, contain incorrect statements. The 10 mW/cm^2 exposure levels are considered totally safe and are not time limited. Although microwave radiation exposures can produce cataracts

requires a power density greater than 100 mW/cm^2 applied for more than an hour to cause such injury. We know of no data to substantiate the claims concerning phased array fields being less dangerous than conventional search radar. It is our experience that RF energy will be measured at ground level in the scan sector of the PAVE PAWS radar (see AN/FPS 85 and PAR reports forwarded 11 Sep 75). We could not support the "bird" statements. Appendix V, paragraphs 1.2.2.1, 1.2.2.4, and 1.4 should be rewritten to be consistent with the data/comments provided herein. The last page of Attachment 4, concerning Mainbeam Hazard Distances, contains outdated information from AFM 161-7 (superseded by AFR 161-42).

d. The Radiobiology Division of the USAF School of Aerospace Medicine (USAFSAM/RA) has started a research program to evaluate the effect of PAVE PAWS (Phased Array Radar) RF emission on man. A letter report was forwarded 11 Sep 75. Man-equivalent models will be developed to evaluate energy absorption and distribution profiles, and a series of bioeffects studies will be performed. Follow on studies should provide a meaningful data base to assess the effects of 400-450 MHz phased array radar on man. A requirement for such data is documented in the tri-Service EMR research program.

e. Current program plans do not consider the effects of PAVE PAWS on wildlife. Guidance concerning this requirement and appropriate AMD/SAM response has been requested from AFSC/SGB. As an interim measure, the Electromagnetic Compatibility Analysis Center (ECAC) could provide you with the number of high power radar and communications systems that exceed the effective radiated power (ERP) of PAVE PAWS and are located throughout the CONUS. The number and their ERPs should be impressive. It can probably be stated that there have been no apparent radiation-induced changes in the environment (flora and fauna) around these sites. Specific statements could probably be obtained from several sites such as Eglin (AN/FPS-85).

3. This Division could provide better support if the SPOs would identify requirements earlier and provide us with early draft copies of documents such as the referenced environmental assessment.

FOR THE COMMANDER

JOHN E. PICKERING
Chief, Radiobiology Division